CROSS-AGE TUTORING AND THE DEVELOPMENT OF THREE THINKING STRATEGIES IN ADDITION

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This research study contains no material which has been accepted for the award of any other degree or diploma in any tertiary institution. To the best of my knowledge and belief, this study contains no material previously published or written by another person, except when due reference is made in the text of the research study.

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ABSTRACT

This study explored the effects of cross-age tutoring as an instructional mode in the development of thinking skills in Mathematics. Six mixed-ability Grade One students were tutored by six high-ability Grade 6 students in three thinking strategies in addition. A tutoring model was developed to facilitate more effective tutoring of the thinking skills. The tutors *modelled*, *rehearsed*, allowed their students to *apply* the strategy and encouraged students to *reflect* on what they had done. This model was later modified as a result of the research findings. Subjects were tutored daily over a four week period in the 'min' model, Near Doubles and Build to Ten strategies. Tutor-student interactions were recorded. A Tutoring Scaffolds Protocol was developed to categorise tutors' scaffolds. A significant similarity was found in the techniques that tutors use to correct students' responses. To assist in developing understandings of the tutoring process tutor responses were placed within the six scaffolded functions proposed in the work of Wood, Bruner and Ross (1976). A model of tutors' repair strategies was proposed to explain tutors' scaffolding functions.

It was concluded that tutoring was an effective method for teaching thinking skills when it was used with other activities that encourage the development of shared understandings of the learning process. It was proposed that repair strategies offered by the tutors could be taught in tutor training sessions, thereby fostering the metacognitive understandings of students involved in tutoring programs.

CHAPTER 1

INTRODUCTION

1.1 Introduction

This study explores the role cross-age tutoring can play in the development of children's thinking skills in addition. Peer tutoring is an instructional mode which involves children of the same age teaching each other. Cross-age tutoring is when older children teach younger students. The introduction presents relevant issues in children's strategy development. In order to present these issues logically the introduction has been divided into four sections. After a general introduction the first section explains and discusses the important role that metacognitive thought plays in strategy development. Section two discusses instructional modes, the teaching of thinking skills and concerns over the effectiveness and durability of taught strategies. The third section discusses the role that scaffolded instruction could play in the teaching of thinking skills. The last section explains the research problem and clarifies the focus of the study.

> A child's mind is like a workshop. This workshop contains a remarkable collection of materials (knowledge) and tools (learning processes) that can be used to make new products (rules, strategies, hypotheses, schema, causal networks, etc.). Some of the tools and networks are useful for a great many tasks. Many others are specialised for a particular purpose, but are invaluable when they are needed. (Siegler & Jenkins, 1989, p. 1)

One of the most notable characteristics of children's cognitive development is the formation of thinking strategies. Children learn to monitor and regulate their cognitive resources impressively in many different ways and situations. Each child has individual strategies for directing attention, memorising facts and dealing with new information. Children are in a sense universal novices (Brown & Deloache, 1978). They constantly find themselves in problem situations that adults solve as part of their everyday lives. Cognitive tools as Siegler and Jenkins suggest can have wider applications to other situations. Thinking strategies can be transferred to assist in new tasks. Links can be established between different domains and the usefulness of strategies can be assessed in other contexts.

Siegler and Jenkins' workshop analogy is consistent with modern theories of information processing and beliefs that children actively construct knowledge. Constructivist theory in its most basic form has two fundamental principles. Firstly individuals are not empty vessels into which knowledge and information are poured: They are active organisms who construct knowledge from outside stimuli provided by their environment. The experience of coming to know is an adaptive process involving organisation of the learner's *existing* network of concepts and constructs. Secondly learning does not occur because of the learner's discovery of a pre-existing world that is imposed from outside. In educational settings, constructivism implies teachers should provide student centred, transformational experiences that involve an interventionist style of teaching that is concerned with directly asking and stimulating questions that will lead to an understanding of subject matter within children's existing cognitive frameworks.

Chance (1986, p. 3) observes that the world has entered a "post industrial information age" in which the use of information will become the key skill of the future. This technological revolution has led to a redefinition of the purpose of teaching and learning in schools in the last decades of this century. Evans (1991, p. 7) concludes that:

Amid social and technological change, one of the most valued outcomes of education may well be young people who are adaptable in their learning and their actions. Successful adaptability requires not only a wealth of propositional knowledge and specific procedures, but also the ability to modify and control them.

A growing array of authors and researchers have bemoaned the inability of students to think critically and analytically. Central to this concern is the failure of school curricula to supply learning experiences that require students to consider possibilities beyond the recall of knowledge or information (Brown & Smiley, 1977; Durkin, 1978; National Assessment of Educational Progress, 1980; Sitronik, 1983).

The teaching of thinking strategies has emerged as a "hot topic" in recent years (Pressley, 1990 p. 7). There is a great deal of evidence to support the idea that teaching of learning strategies improves cognitive performance in a wide range of populations (Scott, 1988; Mulcahy, 1980; Jones, 1986; Schoenfeld, 1985; Deschler, Schumaker & Lenz, 1984). Furthermore there has been a call for the explicit teaching of learning strategies (Weinstein & Mayer, 1986; Borkowski, Carr & Pressley, 1987). As a result there have been an abundance of programs developed to improve students' thinking skills. For a comprehensive review of these programs see Nickerson, Perkins and Smith (1985) and Chance (1986).

1.2 Metacognition and Strategy Development

Implicit in these ideas about developing thinking skills is the understanding that children can actively monitor, change and control their thinking processes. Metacognition is essentially the "*how*" of the thinking processes that occurs during learning. John Flavell's studies in the early 1970's were the trigger for massive interest in the area of metacognition. Initially in his early writing Flavell defined metacognition as "knowledge and cognition about cognitive objects, that is about anything cognitive" (Flavell, 1987, p.21).

One area in which Flavell has promoted a great deal of research is comprehension monitoring, which Flavell (1977, p. 178) defines as " awareness and regulation of ones own listening and/or reading comprehension." This has led to research into new methods of teaching strategies for comprehension in children (Paris, Cross & Lipson, 1984).

Flavell's most notable contribution to the awareness and the teaching and learning of metacognitive skills was his development of a taxonomy of the metacognitive domain. He categorised metacognition into metacognitive knowledge and metacognitive experience. Metacognitive knowledge is "one's acquired world knowledge that has to do with cognitive matters" (Flavell, 1987, p. 21). Flavell divided metacognitive knowledge into three categories: person, task, and strategy knowledge. Person knowledge was sub-divided into three more categories of intraindividual, interindividual and universal. Intraindividual variables occur within people: These are personal judgements about the individual as a thinker and in what situations successful thinking takes place. An example is a child knowing he/she is better at Mathematics than Reading. Interindividual variables involve people comparing the thinking aptitudes of other individuals, for example, knowing that one friend is more reflective than another. The final subcategory refers to the acquired knowledge we gain from living in our culture. Flavell believed that this universal area provided order for peoples' lives in offering a shared understanding of the intricacies of living in society.

Task variables involve ones knowledge of the task. Individuals acquire knowledge about the tasks in which they are engaged. Understandings are developed regarding the difficulty, constraints and long term effects of different tasks. The nature of the task can trigger certain ways of working among learners who have well developed metacognitive abilities. A difficult passage of prose or a complex looking theorem, for example, warns the learner to proceed more slowly or to check for meaning before proceeding. According to Flavell children learn that different cognitive tasks require different kinds of mental processes. Highly developed thinkers have a bank of previously used cognitive routines that they can apply to differing situations. Flavell warns that some students may never learn to effectively use their knowledge of task variables. Therefore he urged teachers to teach these skills and to intervene in learning situations to emphasise the learning methods of others. Brown (1987) argues that the development of such skills are too crucial to be left to chance and that the poor performances of some students may be directly related to a lack of awareness of task variable metacognition.

The third metacognitive variables are strategy variables. Strategy variables refer to how to proceed directly with a task or towards a goal. It is here Flavell (1977) distinguishes between cognitive and metacognitive strategies. According to Flavell a cognitive strategy is designed simply to get to some cognitive goal or sub-goal whereas metacognitive strategies are for monitoring cognitive progress, such as reading numbers to check an answer. In the learning environment the three elements person, task and strategy variables interact. Efficient metacognitive thinkers are involved in making decisions on the basis of these variables, that is, what they know about themselves as thinkers, the strengths and weaknesses of different strategies, and the people who work with them in the learning environment.

The other important area in Flavell's taxonomy relates to metacognitive experiences which can be simply defined as an individuals conscious awareness of his/her thinking. Manning (1991) provides the example of driving on a familiar route and having no recollection of towns and landmarks along the way. Driving along the route has become so automatic that cognitive resources are devoted to other more pressing tasks. The individual clearly has two choices: To ignore the signal that has been received or to act on it, and therefore use it to regulate future attention and behaviour. Flavell says (1987, p.27) that these experiences are most likely when the cognitive task is somewhere between familiar and totally unfamiliar. If we return to Manning's example, driving on some roads is so familiar that we sometimes do not consciously monitor irrelevant places or occurrences during the journey. Conversely a situation can be so unfamiliar to us that we cannot monitor what is occurring because we would be unaware of the relevance or interrelation of particular stimuli.

Metacognitive experiences are also likely to occur when it is important to make correct responses. In a group teaching situation if the teacher gives each student a number and then calls out numbers at random to respond to questions, most group members will consciously monitor their thinking. Metacognitive experiences are also likely to occur when a person is in disequilibrium. A person searching for lost keys will cognitively monitor every place he/she has been with the keys in an attempt to recall their location.

Clearly the importance of metacognition in children's learning is crucial in their progress towards more competent thinking patterns. Children can enhance their learning by becoming aware of their metacognitive thinking. Through this awareness students can develop responsibility for monitoring their own learning, thereby developing insights and control of the learning process. In turn, by raising their consciousness of their own thinking students can truly become independent learners.

A number of influential research studies have supported the central role of metacognition in cognitive development (Paris & Lindauer, 1982; Brown, Bransford, Ferrara & Campione, 1983; Pressley, Borkowski & O'Sullivan, 1985). The implications of this research for teachers is clear. Children need to be *taught* how to think. They need to be *shown* methods, for example, for memorising information, comprehending written passages and organising information into meaningful "chunks." It is these methods that the next section is concerned with.

1.3 Instructional Modes, the Teaching of Thinking Skills and Concerns over the Effectiveness and Durability of Taught Strategies

A fundamental question for educators involves the selection of instructional modes that are the most appropriate for the development of mature and proficient thinking strategies. Any instructional mode developed to teach these skills needs to have at its core interventions that actively facilitate learners' metacognitive thought and control of memory and attention. Furthermore strategies that are taught need to be readily transferable to new and novel situations thereby developing within each child a useful selection of cognitive tools.

Direct explanation has long been seen by researchers as a efficient instructional mode for the teaching of learning strategies (Paris, Cross & Lipson, 1984; Duffy & Roehler, 1986). Concern exists however over the effectiveness and durability of taught strategies. Children do not readily transfer strategies taught to them (Belmont, Butterfeld & Ferretti, 1982; Pressley, 1979; Campione, Brown & Ferrera, 1982; Rohwer & Litronik, 1983). In Mathematics Cobb (1988) suggested that unless teachers address children's knowledge structures a separation can develop between children's understandings and school conceptions of the mathematical domain. This leads to students regarding mathematical strategies and processes as being unrelated to their own cognitive routines. Cobb's separation can lead to Mathematics being seen as

> an isolated self contained context in which the possibility of doing anything other than attempting to recall prescribed methods does not arise (p. 98).

Cobb highlighted students' completely unreasonable answers to problems as evidence of this separation of mathematical understandings.

Christensen (1991) in her study of "Instruction, Practice and Addition Strategies" examined the strategy development of forty Grade One students who were randomly allocated into two groups. One group received teacher directed instruction in three addition strategies. The other group was involved in drill and practice activities. Christensen hypothesised that the strategy training group would perform better than the drill and practice group. Interestingly, the practice group performed as well, or better than the strategy training group. In accounting for these findings Christensen theorised that

> the strategies which were taught did not fit comfortably into children's existing cognitive routines. Therefore the strategies were ignored. This contrasts with the practice group, where children spontaneously developed and used the strategies although they were not explicitly taught. This suggests the hypothesis that practice facilitates cognitive change, so that strategies become an integral part of students' mathematical knowledge rather than an irrelevant appendage to their understandings (p. 66).

Cumming (cited in Christensen, 1991) in a doctoral thesis examined the influence of instruction on the addition strategies of 130 children from Grades 2 to 6. Cumming concluded that although children were taught strategies in addition, few students used them. Strategies that were used developed spontaneously. Christensen (1991) speculated instruction that involved students inventing strategies under a teacher's guidance offered a potential solution to those students who rejected teacher-taught strategies. This discovery could lead to students' owning a strategy and therefore it would become part of their cognitive routines. The combination of the teacher's interventionist expertise with a learning environment that is essentially based on experimentation, discovery and two-way communication, could produce better results than teacher directed instruction that involved a one-way communication that was *from* the teacher *to* the student.

Such ideas are particularly attractive to educators attempting to account for individual differences in traditional classrooms. Instruction on such an individualised basis however is problematic for classroom teachers. Lortie (1975) found that lack of time was a pressing concern for many teachers. Teacher intervention that is so time consuming and contains such student-specific techniques and instructional materials appears to be unworkable. Clearly there is a need for an instructional mode that enables students to make individualised guided discoveries of strategies.

1.4 Scaffolded Instruction and the Teaching of Thinking Skills

One area of instruction that offers considerable promise in the development of thinking skills is scaffolded instruction. The most important feature of scaffolded instruction is the dialogue that occurs between teacher and learner. The theoretical foundation of scaffolded instruction is based on the work of Vygotsky (1978), Wertsch (1979) and Feuerstein (1980). They believed that language was the substance of thought, which in turn directed action and that meaningful words spoken to oneself guide and regulate human behaviour. According to Vygotsky a child's intellectual development is framed by the verbal environment created within the social interaction of the child and adult, and that "speech structures become the basic structures of their thinking" (Vygotsky, 1962 p. 51). Vygotsky proposed that speech becomes verbal thought through the development of three stages: external, egocentric, and inner speech. At first external adult speech regulates the very young child. The egocentric speech stage involves overt sub-vocalisations. The three sub-stages in egocentric speech are (i) the child acts and then verbalises about its behaviour.(ii) the child then acts and speaks simultaneously. (iii) the child then begins to cognitively control action using self speech to plan and regulate behaviour. Inner speech is the final stage in which self-talk guides action. Vygotsky claimed that if individuals are stressed or disoriented they will often revert to private overt speech (talking to oneself) to control their attention.

The progression through the stages above has often been labelled as a progression from an *interpsychological* plane of functioning towards a *intrapsychological* level. Talk that is external and overt gradually becomes internal speech that forms the framework of mental self-regulation. Learning is therefore taking place on two levels. On one level learning about the *task* is occurring. On another learning about perceptions of *structure* are being made within the individual's cognitive framework. Although there has been considerable debate over Vygotsky's theory of verbal regulation one area of general agreement has been that planful behaviour is based on verbal thought. Verbal self-regulation relates to metacognition specifically because it involves awareness and control of human behaviour.

Vygotsky's (1978) highly influential work, "Mind in Society", promoted the idea of a zone of proximal development (Z.P.D.). This was defined as

> the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers (p. 86).

Learning, to Vygotsky, was an intensely social event involving the interaction of language and not an independent labour that could be meaningless without adult assistance and interpretation. Social learning, according to Vygotsky, was the method through which children could develop higher psychological processes. Children could advance their consciousness and most importantly their *control* of psychological processes with the guidance of adults and capable peers. The assistance provided by these outside agents is naturally slightly above the independent level of the child. Implicit in the ideas of the Z.P.D. is an understanding that the zones of different children may be of varying sizes (Brown & Ferrara, 1985). A child whose unassisted efforts are a long way below his/her assisted efforts could be said to have a wide zone of proximal development (Day, 1983). Figure 1 provides a visual representation of the Z. P. D

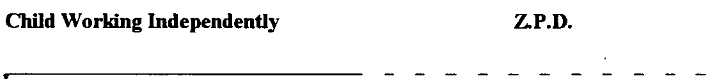


Figure 1. A representation of the Zone of Proximal Development

The adult or capable child provides a temporary support or as Bruner (1985, p. 25) called it, "scaffolding." As the child becomes more competent in the difficult parts of the task the adult or capable peer develops the child by allowing him/her to take over more of the task. This was referred to by Bruner (1985) as "fading" and is a crucial aspect of ceding control from the adult or capable peer to the learner. This allows the student's understandings of concepts and skills to be tested whilst still remaining in the security of the tutoring relationship.

Wood, Bruner and Ross (1976, p. 98) explained the role of tutoring in problem solving. Wood, et al. categorised the functions of tutoring (scaffolding functions) as follows.

1. *Recruitment.*

The tutor's first and obvious task is to develop the problems solver's interest in beginning the activity and involvement in understanding the requirements of the task.

2. *Reduction of degrees of freedom.*

This involves the simplification of tasks by reducing the number of acts to a workable number for the problem solver.

3. *Direction Maintenance.*

Learners can lag and regress to other aims. It is the tutor's role to keep them in pursuit of a particular objective. It involves keeping the child in the field and partly the deployment of zest and sympathy to keep the problem solver motivated.

4. *Marking critical features.*

A tutor gives the learner messages that certain features of the task are relevant. This involves marking the discrepancies between what the child produces and what the tutor considers to be the correct production. The tutor's task is to interpret discrepancies.

5. *Frustration control.*

The major risk in the tutoring environment is the creation of too much dependence on the tutor by the learner. The tutor's job here is to release the student's reliance gently and in a positive fashion.

6. *Demonstration.*

Demonstrating or modelling solutions to tasks when closely observed involves considerably more than simply performing in the presence of the tutee. It involves the idealisation of the act to be performed and it may even involve completion or even explication of a solution already partially executed by the tutee. In this sense the tutor is imitating an idealised form of the response he/she wants the student to complete when the student next attempts the task. Inherent in this process is the tutor's understanding as to what are the difficult parts of the task. Extra emphasis is given to these steps.

Wood, Wood and Middleton (1978) explored the importance of instruction that was aimed within children's Z.P.D. The study involved an experimental manipulation of teaching strategies in tutoring involving three to five year old children in a block construction activity. Although this study concentrated on child-parent interactions, an instructor was selected to work with the children, and therefore the results in this study are relevant to developing understandings of tutoring in a school context. They identified four teaching styles (contingent, verbal, swing and demonstration) which were characteristic of different parents. The intervention of the tutor within the differing teaching strategies was altered in keeping with the strategy.

Contingent instruction was nearest to the tutoring model provided by Vygotsky (1978) and Wood, et al. (1976). Students in the contingent group were presented with problems, set particular goals and were requested to work at levels that lay just beyond their current level of independent ability. If the child was successful in following an instruction less assistance was offered on the next attempt. If the child failed more assistance was provided. Verbal instruction used verbal prompts extensively. Verbal prompts were not augmented by demonstration. This strategy proved to be very frustrating for the subjects because lack of demonstration meant that instructions were not concrete enough for the subjects to understand. The swing strategy was, as the name suggests, a strategy of extremes. If the child failed to understand a verbal prompt he/she was shown what to do after which instruction was supplemented only by verbal prompts. The demonstration group was shown what to do without the instructor verbally explaining her actions. The contingent group proved to be more efficient in their constructions and required fewer attempts to be successful.

Perhaps the most influential work in the social exchange of shared knowledge are the reciprocal teaching programs in reading developed by Palincsar and Brown (1984).

These programs aimed to develop children's comprehension skills through an interactive dialogue between students and teachers. The most interesting aspect of reciprocal teaching was the changing roles of the participants. As the children's competence and confidence improved their role changed into that of the teacher. They went into other reading groups and coached younger children on reading strategies. The teacher's role changed from a direct form of instruction (early on in the program teachers explicitly modelled the strategies) to that of a coach whose intervention became more and more specialised towards the individual student's needs. Four strategies were taught (Palincsar & Brown, 1984, p. 119).

1. *Summarising*: identifying and paraphrasing the main ideas of the text.
2. *Question-Generating*: self questioning about the type of information that is generally taped on tests of comprehension and recall.
3. *Clarifying:* discerning when there has been a breakdown in comprehension and taking the necessary action to restore meaning.
4. *Predicting*: hypothesising the structure and content of the text that was to be presented next.

Palincsar, Brown and Martin (1987) also found this form of instruction could be used with younger children in Grade 1 and early high school students. Fantuzzo, Riggio, Connelly and Dimeff (1989) extended the reciprocal teaching paradigm to the college level. In their program each student was required to develop a set of main idea questions, answers and justifications for set materials. Students then tested each other and discussed the answers. The findings of Fantuzzo et al. reinforced the earlier thoughts of Palincsar and Brown that reciprocal tutoring improves classroom performance. In addition Fantuzzo, et al. found that reciprocal teaching had affective benefits as well. Students in this study reported that they were less fearful of negative results and fewer incidences of depression were reported.

Whimbey and Lochhead (1982) used reciprocal pairings with college students to teach problem solving strategies. Reciprocal pairs involve students teaching and then reversing the situation with the partner to become the learner. Whimbey used reciprocal pairing to positively reinforce the learner with an expert opinion as the student was explaining an idea out loud. Whimbey's teaching program (1982) strongly supported the use of tutoring in the teaching of thinking strategies. Moore (1988) found that reciprocal teaching held considerable promise in encouraging students to develop shared understandings of learning strategies.

Much of the literature on the teaching of thinking skills has focussed narrowly on the direct teaching of thinking skills (Pressley, 1990; Nickerson et al., 1985). Although Rowe (1991) does not back up her argument with any empirical research, she maintains that the use of peer teaching can be useful in making explicit to students the methods that tutors use to learn, study and to problem solve.

1.5 The Focus of this Study

Scaffolded instruction seems to hold considerable promise in the teaching of thinking skills in that it develops shared understandings of unseen complex cognitive processes. Tracing instructional interactions could provide interesting perceptions on the ways that students acquire, develop and modify strategies. The importance of this study is that it presents a snapshot of strategy acquisition in a school setting and presents general perceptions of the way children see themselves as strategic thinkers.

Christensen's (1991) well documented study provides clear direction for an examination of scaffolded instruction in the teaching of addition strategies. Christensen's hypothesis that the direct teaching of thinking skills was not as effective as drill and practice in the acquisition of addition strategies is premised on the comparison of the results of drill with direct (teacher) instruction. This paper proposes that scaffolded instruction involves considerable benefits in the teaching of thinking strategies because of the rich interplay of language and understandings that are developed in a caring, individualised learning environment. Furthermore, it is hypothesised that scaffolded instruction readily develops metacognitive thought and understandings that lead to the acceptance of taught strategies into children's cognitive structures.

This research project was designed in order to specifically examine the influence of cross-age tutoring on young children's development of thinking strategies in addition. It was the researcher's intention to develop clear understandings of Grade One subjects' strategy acquisition. Therefore a small group of six subjects was chosen so that individual strategy development could be studied in some detail. The subjects who were chosen represented a cross section of abilities found in a Grade One class. This allowed the researcher to ascertain the effectiveness of scaffolded instruction on students of different ability levels. Tutors were trained and taught to use a new tutoring model that was developed by the researcher. Due to the concentration on these individual aspects of strategy development the duration of the tutoring program ran for an intensive four week period. Oral reporting and written tests were used to measure the development of strategies. Tutor-student interactions were recorded on tape. This enabled the researcher to examine the methods that tutors used to teach the subjects.

Several limitations of this study need to be mentioned at this point. Durability of strategies taught by the tutors was not measured by any kind of delayed posttest. No comparison group was set up to examine the differences between the tutored and non-tutored students in the class. Therefore caution should be exercised in transferring the findings of this study to broader educational contexts.

The paper has been arranged as follows. Chapter Two, the review of related literature, is divided into two parts. Part One briefly examines the relevant aspects of peer and cross-age tutoring. Part Two discusses children's early strategies in addition. Chapter Three explains the research methodology used. Following a general outline of the methodology a tutoring model (M.R.A.R.) that was used by the tutors is presented. Then the research methods and procedure are explained. Chapter Four presents the results of the Oral and Written Pretests and Posttests. Tutor-student recordings are analysed. The Tutor Scaffolds Protocol that was used to categorise the scaffolds of the tutors is presented and explained. Transcripts of tutor-tutee talk are provided where appropriate. Chapter Five discusses the findings of the study. A scaffold repair model is presented that suggests that repair scaffolds provided by the tutors to correct students followed a similar pattern. The conclusion includes general ideas for the use of tutoring in strategy development and possible directions for further research.

CHAPTER 2

REVIEW OF RELATED LITERATURE

2.1 Introduction

Peer tutoring is one of the oldest instructional modes known to educators. In its purest form it involves learners helping each other and learning through teaching. It has been used in many educational settings and with diverse populations. The first section of this chapter will discuss peer tutoring. The first part of the tutoring section will briefly trace the use of peer tutoring in schools from ancient times to the present day. The scope of peer tutoring, the effectiveness of tutoring programs, peer tutoring in reading and peer tutoring programs in Mathematics will also be examined.

The second section of this chapter contains a review of literature that examines important research findings and theoretical considerations in children's addition.

2.2 Peer Tutoring

2.2.1. Peer Tutoring in the Ancient World

Peer tutoring is not a new idea. Tutoring has existed since the earliest times. In ancient Greek education Aristotle used archons and student leaders to assist him in the more routine areas of instruction. Greece became a Roman province in 146 B.C., and naturally came under the influence of Roman educators. In classical Roman education "litteratores" were used as teachers. These boys tested other children on basic sight word skills, syllabification and became involved in dictation and grammar activities (Wise, 1964, p. 14).

Quintilian, (born A. D. 40), the Roman Professor of Oratory, in his treatise on education, the "Institutio Oratoria", maintained that younger students could learn much from older children in a class situation (Dillner, 1971, p. 3).

2.2.2 The Tutorial Innovations of Andrew Bell

The first *systematic* use of peer tutoring was by Andrew Bell, who was born in Britain in 1753 (Topping, 1987, p. 13). Bell travelled to India, and became superintendant of the Madras asylum in 1789. Bell had noticed that the children in his care found it particularly difficult to acquire and remember the letters of the alphabet. Bell struck on the idea of using the sand in the playground as a teaching aid, i. e. allowing the students to draw their letters in the sand. The teachers dismissed the idea. Bell sacked his teaching staff and completely reorganised the school around an army of student tutors. Bell's system involved organising students into pairs, one child being the tutor the other the learner. The tutors were supervised by assistant teachers. Assistant teachers were answerable to a teacher, who in turn reported to an "usher ", who was supervised by the school master. Bell's system utilised interesting innovations that were ahead of their time, such as grouping children according to their chronological age. Although Bell was interested in the tutoring of basic literacy and numeracy, he certainly was aware of the social benefits of tutoring. Bell stated that his scheme "cultivates the best dispositions of the heart by teaching children to take an early and well directed interest in the welfare of one another" (Gill, 1889, p. 21).

2.2.3 Joseph Lancaster and his Monitorial System

Lancaster was born in Southwark, England in 1778. He developed a monitorial system of school instruction. The system used student monitors who effectively implemented the educational programs of the school. The master of the school instructed the monitors, who then drilled the other pupils. The school was arranged in classes or forms. Within these forms a monitor was allocated a group of about ten boys. The two fundamental aspects of the Lancastrian system were, "order and emulation" (Darton, 1909 p. 898). Schools were regulated in a military manner, commands were issued and reverberated throughout the whole school. Interestingly, Lancaster did not approve of corporal punishment. He insisted on student management strategies that relied on, "shame rather than pain" (Cubberly, 1920, p. 525). Students were ranked by using a leather thong that hung from particular buttons on the child's tunic. Scholarly students were rewarded with greater responsibility and privilege. The Lancastrian system of instruction was an attempt to bring a basic level of literacy and numeracy to the masses of Britain. It was, as Lancaster espoused, a very cheap way to educate a large group of needy children. Students sometimes did not have books or desks, and did not always have slates. The main advantage of such a system was that large schools could be organised around a few teachers, who could oversee masses of monitors and programs of work. It is interesting to note that some of Lancaster's other innovations have remained with us to the present day. He localised the curriculum into discrete areas of study. These subjects included Religion, Mathematics and Spelling.

2.2.4 The Use of Peer Tutoring in Single Teacher Schools

The peer tutoring that occurred in the early years of the State Education systems in Britain, the United States and Australia was in response to large class sizes, few suitably qualified teachers, and few, if any, teaching aids. It was not uncommon for teachers to be in control of 50 to 60 students in a class that varied in age from early childhood to secondary level. This situation occurred predominantly in one teacher rural schools. The teacher had little choice but to enlist the assistance of older, more capable students in the education of the younger pupils. Tutors were often the older brothers or sisters of the tutees. The teacher employed techniques of vertical grouping: the children were grouped according to their ability rather than their age. Tutors supervised children in rote learning tasks such as table work, poetry recitations, and spelling drills.

2.2.5 Peer Tutoring in the Twentieth Century

Peer tutoring in the twentieth century gathered momentum in the early nineteen sixties. It was used as a response to the problems that were developing in inner-city schools in the larger American cities. Literacy and numeracy rates amongst these students were low and there were high rates of truancy, violent juvenile crime and drug abuse. Melargno and Newmark (1971) in their “Tutorial Community” targeted these ethnic minority, low income populations. Many educators saw peer tutoring as a way of making school more relevant for children by developing the self esteem and social skills of students by allowing them to take more control and responsibility for their own learning. The "Tutorial Community" program of Melargno and Newmark targeted these ethnic minority populations with a well structured training strategy (see Allen, 1976 for a summary of the project). In fact Melargno developed a whole primary school community that was tutored by a nearby High School. By 1974, he claimed that 10,000 schools in the U.S.A were involved in some form of tutoring project.

In 1975 Charconnet produced a U N E S C O funded paper that highlighted the ways peer tutoring could be used in the emerging Third World countries of Africa. The influential Times Educational Supplement ran a series of articles on peer tutoring in 1974 (Briggs, 1974). In the late nineteen sixties Sinclair Goodlad reviewed the principles of peer teaching in a distinctly British context, in his work "Learning by Teaching-An Introduction to Tutoring" (Goodlad & Hirst, 1989). He also discussed some projects he had supervised and examined in the greater London area.

In Britain the focus of peer tutoring has been different to the approach in the United States. In America the broad aim has been to improve the academic achievement of students. Underlying this was a desire for peer tutoring to repair the damage (as some saw it) to the structure of American society. In Britain there have been tutoring projects which have attempted to replicate the work of Melargno in city schools, in comparison the British focus has remained on a narrower tack, by using tutoring in more specific and esoteric curriculum areas, for example reading and spelling. The American use of peer tutoring as Topping (1987) observes, is to turn the tutors into 'mini teachers', whereas in British schools tutoring is essentially a tool that is used by teachers in certain favourable situations. Australian teachers have tended to follow the British model.

2.2.6 The Scope of Peer Tutoring in Schools

Tutoring has been used in many diverse ways and situations. Adult Literacy tuition has been in operation for years in many countries around the world. Adults have coached each other in Foreign Language teaching (Carsrud, 1984). Teacherless groups have been used in English universities since the early 1980's (Collier, 1980).

Peer tutoring in schools has been used to assist those children who are perceived as having some problem of difficulty and who need extra practice. It has been used widely in the cognitive and the affective domains. Peer tutoring has branched into most areas of the curriculum. Tutoring has been used in the areas of Mathematics (Boehm, 1970) and

Reading (Sindelar, 1982). It has been used in Creative Writing (Bell, 1981), Editing skills (Kariegnes, Pascarella & Pflaum, 1980), Science (Hendelman & Boss, 1986) and Foreign Languages (Fitzgibbon & Reay, 1982).

In the affective domain peer tutoring has been used to assist children with social problems. Peer counselling was found by Warner and Scott (1974) and Strain (1981) to be at least as effective as professional counselling. Posen's (1983) study extended these ideas to counselling violent male offenders in secondary schools. He used these offenders as tutors with quite impressive results. In a similar vein Murfitt and Thomas (1983) used peer tutoring as a means of developing and maintaining the self esteem of underachieving primary school children.

Lawrence (1972), Lancioni (1982) and Goldstein and Wickstrom (1986) have successfully integrated handicapped and, in Lancioni's case, autistic children into mainstream classes by well structured peer tutoring and peer support techniques. Peer tutoring has also been used in sexuality education and drug rehabilitation (Topping, 1987). More recently peer tutoring has been refined into reciprocal tutoring which as the name suggests involves the reversal of roles within the pair situation (Palincsar & Brown, 1984). Reciprocal teaching highlights the recent interest that exists for a program that can provide the benefits of tutoring and being tutored together for one child.

2.2.7 How Effective is Peer Tutoring?

Throughout many of the summaries and analyses of research on peer tutoring there is a tension between what is regarded as good and bad research methodology. This stems from the tension that exists between the more traditional forms of educational research and more "modern" techniques. This is a particularly important question when we consider the many social and interpersonal improvements that are claimed in peer tutoring research. Self esteem and changes in attitude can be very difficult to measure. It is understandable that some scholars have a genuine concern with the qualitative approaches taken in some studies, such as child observations, and regard these as not being valid research.

The first major review of peer tutoring by Feldman, Devin-Sheehan and Allen (1976) found that some well controlled research had been completed, although these studies were in the minority. Feldman et al. argued that the use of anecdotal reports did not conform to the basic rules of sound experimental technique. They concluded that the main benefit of peer tutoring was that it provided considerable benefits to students at both ends of the developmental scale.

Cohen, Kulik, and Kulik (1982) in their meta-analysis (a qualitative review of research findings) reduced five hundred studies on peer tutoring down to sixty-five that they considered were academically rigorous enough in their research designs. Adherence to what was labelled sound research methodology was strict to the point of being rather extreme. Cohen et al. highlighted the fact that dissertation studies and unpublished papers reported smaller effects than those published in educational journals. Begg and Berlin (1988) identified publication bias in the peer tutoring area. Publication bias means that editors of educational journals give precedence to articles that strongly support popular ideas which are in vogue. Studies that did not exhibit the positive statistically significant results for tutoring were simply not published. Understandably Cohen et al. found the benefits of peer tutoring in some cases were overstated. They maintained that their analysis showed only modest improvements in tutors and tutees. In conclusion they found,

> definite and positive effect(s) on the academic performance and attitudes of those who receive tutoring. Tutoring programs also have positive effects on the children who serve as tutors, in attitudes and understanding (Cohen et al., 1982).

Sharpley and Sharpley in their review of peer tutoring in 1981 also concerned themselves with the problems of research design. They specifically drew attention to sample sizes, lack of control groups, and problems with the duration of some studies. Sharpley and Sharpley also became rather concerned about the complete lack of negative findings about any aspect of peer tutoring in their search of the literature.

Peer tutoring remains one of the most well researched areas in education, and despite the concerns with methodology the vast majority of researchers conclude that peer tutoring is a very useful instructional tool. The cognitive benefits for tutees in peer tutoring programs were well documented in early classic research by Klosterman (1970) who found that tutoring was at least as effective as normal classroom instruction. This study also found that tutoring in small groups was as beneficial as individual tutoring. These sentiments were echoed two years later by Bausel, Moody and Walzl (1972) who conducted a study involving a peer teaching group and a control group. Both groups studied sixteen mathematical problems and were later tested. Although both groups had exactly the same duration of instructional time it was deduced by the authors that the instructional time offered in the tutoring group was more effective because it was pitched precisely at the level of the tutee involved. This remains as a key finding in subsequent literature to date, i.e., tutoring time is quality time, because tutors are responsive to the needs of their students. Many studies have found that the cognitive ability of tutors and tutees in a wide array of situations is greatly enhanced by peer tutoring.

2.2.8 Peer Tutoring in Reading

Reading is by far the most frequently mentioned activity in peer tutoring research and literature perhaps because reading is considered the key skill that unlocks the other areas of the curriculum. Reading lends itself naturally to the tutoring process. Children are used to having an adult or even another child listening to them read in a formal or an informal situation. In the United States the work of Niedermeyer and Ellis (1971) is a good example of a rather structured approach to reading tutoring, and reading schemes generally at the time. In a similar vein some associates at Brigham Young University (Von Harrisson & Reay, 1983) developed a course of six reading tasks to be taught in what was called, "The Structured Reading Tutorial." Peer tutoring provided many opportunities for the individualised teaching of skills to occur. These tutorials involved; teaching letter names, letter sounds, blends of sounds, decoding of words that were phonically regular, sight words, and oral reading. Tutoring sessions lasted for twenty-five minutes each day for six weeks. Other teaching resources were developed in the program such as diagnostic tests, records of achievement, flash cards and written activities.

The Structured Reading Tutorial is an example of tutoring programs in reading that are characterised by a tight unyielding format that didn't really suit teachers in busy classrooms. The natural outcome of this was that teachers modified peer tutoring in reading according to their own situations. The result was the paired reading technique. This technique began in Britain and was initially a way in which untrained adults and parents could listen to children and assist them with their home reading. Some paired reading programs were as simple as this: other teachers developed more structured programs according to their needs.

The work of Ted Glynn (1985) in the area of Paired Reading has been very important. He developed a technique which he called "Pause, Prompt, Praise." This technique enables unskilled tutors to assist their tutee by firstly pausing when the tutee has made an error (this is usually for five seconds). The tutor can then prompt the tutee by various means, eg. rereading the passage, leaving out the word, making up a question, or using the picture as a prompt. The tutor then praises the tutee on the correct response. Glynn also invented a knocking technique which allows the tutee to take over the reading by knocking on the table. Paired reading techniques rely on a friendly and trusting rapport between the partners and a shared love of books. Modelling by the tutor of good reading habits is also a very important part of the paired reading process. An important difference between paired reading and the tightly structured American tutoring programs is in the reading material. Students select the books they want to read in paired reading, rather than being forced towards more difficult books. Paired reading has been used to assist elementary school children seen to be in need of extra reading time.

The research of Pumfrey (1986) and Winter (1986) indicated the positive effects of paired reading techniques. Both studies reported gains in reading accuracy and comprehension. Winter (1986) identified greater willingness by students involved in a tutoring program to self correct their own reading after his six week study. Topping (1987) contains a detailed account of a five year paired reading program established in Kirkless, West Yorkshire, England.

2.2.9 Peer Tutoring and the Teaching of Mathematics

Project S.E.E.D. (Special Elementary Education for the Disadvantaged) used professional mathematicians and research scientists to teach mathematics to classes of disadvantaged schoolchildren. Adults tutored whole classes of children who then returned to their classes to tutor their peers. Project S.E.E.D. started in 1963. By 1973 12 000 students were said to be involved in the program (Johntz, 1973). Boehm (1970) successfully used tutoring to teach the Mathematical principle of infinite convergence to sixth-grade students.

Beirne-Smith (1991) in a tutoring program with learning-disabled students suggested that there was no difference in instructional effectiveness between tutoring in number associations and rote memorisation. She explored the effects of peer tutoring on the acquisition of single digit addition facts in primary aged students with learning disabilities. Three methods were compared. Method A subjects were tutored in a count-on method. Method B were tutored using rote memorisation and Method C were a control group involved in normal teacher directed instruction. Method A subjects were presented associated facts in groups of three that stressed interrelationships between the facts. Method B facts were randomly selected. Results of the study supported the use of tutoring for students with learning disabilities.

Johnson and Bailey (1974) conducted a cross-age tutoring experiment that involved fifth-grade students tutoring kindergarten students for 7.5 weeks. The purpose of the study was to determine if fifth-grade tutors could effectively tutor kindergarten students in arithmetic skills that required a great deal of repetition and reinforcement. Students were tutored in counting, number naming and number recognition. A pretest posttest experimental design was used. Results were compared with a control group. The study demonstrated that students involved in the tutoring program made far greater gains in a posttest comparison with the control group.

2.3 Children's Early Addition Strategies

Ever since the study of Brownell and Chazel (1935) considerable debate has taken place over the value of teaching thinking strategies to solve basic addition problems. They examined the performance in addition of thirty-two mixed ability third grade students. Out of a test that involved 100 different addition combinations sixteen sums were chosen for detailed analysis. Ten of the questions were considered to be difficult and the remaining six of average difficulty. Through interviews it was discovered that 39.5% of the combinations were known as memorised facts, 23.8% were incorrectly guessed, 22.7% were solved by counting and 14.1% were solved indirectly. Students were then drilled on number combinations for a month and then the test was readministered. The same thirty-two children were reinterviewed on the sixteen questions. This revealed that 48.8% of the combinations were known as memorised facts. Correct responses rose from 76.2% to 85%. From these data Brownell and Chazel argued that drill "does not guarantee that children will be able to immediately recall combinations" (p. 26).

A later study by Theile (1938) found that there were considerable benefits in teaching children methods that they could use when recall of basic facts deserted them. Swenson (1949) found that teaching children different addition strategies promoted the learning and retention of basic number facts. Swenson (1949) also suggested there was a considerable transfer of knowledge to other similar problems which developed. In direct opposition to these ideas were the connectionists led by Thorndike (1922) who in his book, "The Psychology of Arithmetic", espoused his connectionist principles. Thorndike believed that the teaching of thinking skills was unnecessary and that children would gain understandings by the consistent and well planned use of drill. The drill theorists (Knight, 1930; Smith, 1921) agreed that the development of competency in number work could be achieved most efficiently through drill and practice activities.

Interest in the teaching of thinking strategies was rekindled in the late seventies in the Journal of Research in Mathematics Education. A flurry of papers strenuously argued the merits of the direct teaching of thinking strategies. Central to this argument were differing interpretations of the findings of Brownell and Chazel's original study. Cifarelli and Wheatley (1979) strongly criticised the findings of Brownell and Chazel. To condemn drill as an inefficient method (after an 85% total correct score in the second administration) was, they argued, rather extreme. The authors also maintained that thinking skills were not necessary for the learning of basic facts and questioned whether the teaching of thinking strategies would accomplish the goals of accurate fact learning. In addition, Wheatley's (1976) study also was cited as evidence that strategies stressing understanding in children may prove detrimental to the computational skills of children involved in algorithmic work.

Cifarelli and Wheatley also seized on evidence that thinking strategies "did not eliminate or diminish the use of inefficient strategies such as finger counting" (p. 369). More research, they concluded was necessary to really consider the necessity of strategy training in learning basic addition facts.

Rathmell (1978, 1979) championed the cause of the meaning theorists in his paper that responded to the Cifarelli and Wheatley's concerns. In his original work Rathmell (1978) categorised methods of solving basic facts as mature or immature. Immature methods were developed prior to Grade 2. Thinking strategies that developed beyond Grade 2, according to Rathmell, were mature. In his study of primary grade children, Rathmell found a high correlation between high test scores in basic addition facts and the use of more mature thinking strategies. He proposed that if children were to learn more mature and efficient methods of solving basic facts, these methods had to be taught. Rathmell's argument centred on Brownell and Chazel's conclusion that, "drill alone did not speed up the old methods. Consequently drill alone will tend to speed up these inefficient counting strategies" (p. 375).

Rathmell saw no need to teach children thinking strategies when they were working with basic facts. Memorisation and recall of these facts were within the abilities of most children. Rathmell (1979) called for the teaching of thinking skills to be directed on the difficult or "hard" facts. Drill on its own, according to Rathmell, did not promote connections between known facts and unknown facts. Each fact was taught as a separate entity. To expect children to learn all the facts they had to know in this way Rathmell argued was untenable. The linking of different facts through the teaching of thinking strategies was important to allow children to easily remember and recall facts. This would in turn encourage the development towards more mature addition processes. The use of drill Rathmell proposed was useful when it was combined *with* the teaching of thinking strategies.

Thornton (1978) strongly backed up the ideas of Rathmell in her study that explored the effectiveness of teaching thinking skills in the four basic operations. Thornton analysed results in two parallel investigations of forty-seven Grade Four and forty-three Grade Two mixed-ability students over an eight week period. Each year group was divided into two experimental groups that received either traditional drill teaching of facts, or instruction in thinking strategies. Thornton concluded that the teaching of thinking skills assisted children in solving harder addition facts.

The work of Steinberg (1985) complemented Thornton's earlier study. Steinberg's eight week uncontrolled pretest-posttest study of twenty-three Grade 2 students focused on strategies that related unknown facts to known facts. These strategies were called Derived Fact Strategies (D.F.S.). Subjects were interviewed four times to assess their use of D.F.S. This study not only attested to the success of using thinking strategies to develop children's basic addition facts, it also revealed that students as young as Grade 2 were capable of using taught thinking strategies reliably.

Christensen (1991) identified two categories of strategies in children's single digit addition. Counting strategies include strategies that require counting in some sequence. Non-counting strategies comprise strategies that relied on the remembering of some information. Furthermore non-counting strategies could be divided into either direct retrieval from memory or thinking strategies. Thinking strategies are invented by children and rely on the use of certain facts that are easy to memorise. Ginsburg (1977) found that each child had a unique set of facts committed to memory which could be used as a basis for thinking strategies. Svenson, Hedenborg and Lingman (1976) identified these as number combinations involving 'doubles' or 'ties' (eg. 3 + 3=□, 2 + 2=□) and addition involving zero (eg. 3 + 0=□).

Perhaps the most important and influential study of children's addition strategies was Groen and Parkman's (1972) analysis of children's development of addition strategies. They used chronometric analysis to show that children develop a variety of counting strategies. Five counting strategies were identified. The 'sum' model was the least efficient and involved children counting all the digits; subsequently this has been called 'count all'. For example in the problem (6 + 4=□) the student would count from one to six and then from seven to ten. 'Sum' model calculations were usually completed with the use of concrete materials (blocks, counters) or fingers. Counting on models were also identified. Counting on is when a child holds a number in their short term memory and counts on from it. Two counting models were identified. These models were dependent on the position of the addend in the number sentence. One involved counting on from the first addend. For example in the sum 7 + 2=□, the child would count from seven to nine. In the other, counting on would occur from the second addend from two to nine. The last two models identified by Groen and Parkman were to do with the magnitude of the addend. When a child used the 'min' model, the child would identify the larger addend and count on from it by the amount of the smaller addend. Hence in the example 6 + 2=□ the student would count on from the larger addend irrespective of its position in the number sentence. This strategy suggests a greater sophistication in a child's understanding of addition, namely that digits can be reversed. The other model was the opposite to the 'min' model;

children identified the smaller addend and counted on from that. Groen and Parkman's study postulated that children of certain ages used a single addition strategy consistently.

The most important finding of the study was that the size of the smaller addend was an excellent predictor of Grade One students' solution times. Therefore the suggestion was that most children of this age consistently use the 'min' model to solve addition problems. The variation of solution times for different problems, they argued, was due to the number of counts up from the larger addend. Hence the solution times to problems in which the smaller addend was the same would be identical, eg. 5 + 3=□, 3 + 7=□, 3 + 8=□. All the examples involve three upward counts. Other researchers (Ashcraft, 1982, 1987; Kaye, Post, Hall & Dineen, 1986) supported the hypothesis that the size of the smaller addend was by far the most reliable predictor of Grade One students' solution times. Svenson (1975) found that group averages as well as individual solution times supported the hypothesis.

Neches (1987) proposed that children rely on four different counting strategies that progress sequentially towards development of the 'min' model. Initially children count all. Following this stage children realise that they are counting the first number in the problem twice. Therefore after counting both sets of blocks they would count on from the first addend. Next the child notices that he/she could count from the first addend without counting from the beginning. Finally the 'min' model is used after children notice and compare the amount of counting that is occurring on inverse problems. In the sums 2 + 4 =□ and 4 + 2 =□ the first involves four upward counts, the second two. It is easier therefore to count up in the question by using the 'min' model. The four is reversed to the beginning of the number sentence and the child counts on by two (four..five.. six).

Conflicts and problems still existed however with children's verbal reports and researchers' statistical data. The major conflict was in children's reports as to *how* they completed addition problems. Carpenter and Moser (1982) and Baroody (1984) reported that children often said they had used more than five different methods to solve addition problems. Fuson (1982) in an examination of children's counting on suggested that children could be using more than one strategy at a time.

Siegler (1987) developed a research study that examined the strategies used by kindergarten, first and second grade students. Siegler combined the methods of chronometric data analysis with children's oral reports of their solution strategies. Siegler found that the chronometric analysis did indeed reveal that the smaller addend size accounted for 75% of the variance of the median times on each sum. Verbal reporting however revealed that children did not consistently use the min model as the chronometric data had suggested. Children reported using five different approaches. Decomposition involves reorganising an unknown problem into two addends that can be more easily calculated. Table 1 explains the children's percentage of use of each strategy.

Siegler (1987) found that where students had indicated they had used the 'min' model the smaller addend was an even better predictor of solution times (86%) than in Groen and Parkman's original work. In problems in which children indicated they had used other methods the smaller addend proved a poor predictor (40%) of solution times. Clearly children were using a variety of methods to solve the problems.

Siegler and Jenkins (1989) in their comprehensive summary of the major issues in children's strategy development in addition argue that the understanding that children use a variety of strategies at one time has profound implications on the way these strategies should be taught. Initially, they argue strategy development has been viewed far too simply as a progression through a series of stages that are dependent on age.

Table 1. Percentage of Use of Each Strategy By Children of Each Age (Siegler, 1987)

	Strategy				
Grade	Retrieval	Min	Decomposition	Count-all	Guess / No Response
Kindergarten	16	30	2	22	30
Grade 1	44	38	9	1	8
Grade 2	45	40	11	0	5
Overall	35	36	7	8	14

Siegler and Jenkins suggest that examination of the interaction between new and old strategies and the developmental progression of such strategies is complex and interrelated. This progression is examined in research by Siegler and Schrager (1984) and Goldman, Pellegrino and Mertz (1988) that concentrated on kindergarten and grade two students. Their research indicates that frequency of the 'sum' strategy steadily declines as retrieval and decomposition steadily increases. This is demonstrated in Table 1. In the case of the 'min' model, frequency increases and then steadily declines as students rely more on retrieval. Count all methods all but disappear as reliance on other more sophisticated strategies develops. Backup strategies are developed by children to support retrieval. Siegler and Jenkins (1989) define backup strategies as any strategy other than retrieval. Back up strategies they argue are used on more difficult problems whereas retrieval is used on simple sums. Siegler and Jenkins (1989, p. 28) conclude.

This pattern of strategy use allows children to strike an effective balance between speed and accuracy. They use the fastest strategy, retrieval most often on problems where they can do so accurately, and use slower backup strategies when they are necessary for accurate performance.

The body of research evidence suggests several important considerations in programs aimed at developing children's addition strategies. Firstly, oral reporting of strategies yields important and individualised data of subjects' choices and beliefs and therefore is of fundamental importance. The practice of viewing strategies in isolation without considering other strategies that may influence or impinge on a child's cognitive routines is problematic. Old strategies are not suddenly discarded as others become more appealing. Some are used as backup strategies and therefore have an important role in developing confidence and the variety of cognitive tools available.

The waxing and waning of different strategies is an intensely personal aspect of each child's mental processing. Often adults put a more complex structure on these developments, searching for understandings premised with terms such as efficiency and order. Children's decisions on why a strategy is chosen vary with motivation, instruction, maturity and are situational. Consider the example of an adult counting a large amount of small change. Despite proficiency in all areas of addition, coins are collected in piles and are counted from one. Many adults find themselves returning to different counting methods in a variety of novel situations.

Any program aimed at strategy development needs to take into consideration the individuality of each child. Therefore whole class instruction seems to be too limiting. Programs that include the development of shared understandings in a close, subject specific environment seem to hold the most promise in the development of strategies that will be actively accommodated into children's modes of thought.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This chapter will be set out as follows. After a general introduction of the research methodology that was used in this paper the **M**odel, **R**ehearse, **A**pply, **R**eflect (M.R.A.R.) tutoring model is explained. Section 3.3 explains the research methods and procedure. The next section explains the tutoring phase. Section 3.5 explains the tutor-student recordings which were an important part of this study. Next the design of the tutoring sessions is summarised and finally the posttest situation is briefly described.

The intention of this study was to explore the development of six mixed-ability grade one children's thinking strategies in addition. The students were involved in a tutoring program for a four week period. Many tutoring experiments (Feldman, Devin-Sheehan & Allen, 1976; Klosterman, 1970) have concentrated on research designs that involve a comparison of tutored and non-tutored students in large experimental groups. Methodologies that attempt to draw such broad generalisations are inappropriate for a study involving itself with children's strategy development. Influential authors in strategy development (Siegler & Jenkins, 1989) and Mathematics (Ginsburg, 1977) stress the individuality of the development of children's cognitive structures. The limitations of the research methodologies described above are that they do not adequately account for these individual differences.

Therefore the focus of this study is limited to specifically understanding the strategy development of a small number of subjects who were chosen to represent the range of ability in a typical classroom. This would enable the researcher to examine which ability levels profited most from tutoring. After tutoring, differences would occur in subjects' strategy development. This could reveal understandings about the effectiveness and relevance of tutoring in strategy training.

Cross-age tutoring was chosen as the instructional mode: it was chosen as the method of instruction for three main reasons. Firstly, tutoring has shown itself to be a very successful instructional mode in many different domains. Secondly, previous work undertaken by the researcher (Beaumont, 1994) indicated that tutoring develops metacognitive thought. The development of metacognitive understandings are fundamental to children's strategy use and their ability to transfer them to other contexts. The final reason is perhaps the most important. There is a paucity of research data on cross-age tutoring and the development of thinking skills.

In her study "Instruction, Practice and Addition strategies" Christensen (1991) found the direct teaching of thinking skills may not be as effective as drill and practice activities. It is the purpose of this study to examine the role that a different instructional mode (cross-age tutoring) could play in the development of children's thinking skills. This study does not attempt to explore Christensen's hypothesis that drill could be more effective than the direct teaching of thinking skills but rather examines the effects of scaffolded instruction on strategy development.

Christensen's pretest-posttest experimental methodology provides a platform for further research. In Christensen's study an Oral Pretest, and a Written Pretest were used. The Oral Pretest recorded children's solution strategies. The Written Pretest was used to measure proficiency in addition and to ascertain which strategies were used when speed of response was of prime importance. This approach will be used in this study of children's addition strategies.

The study also involves a replication of other parts of Christensen's work. As in Christensen's work this study involves teaching three strategies (the 'min' model, Near Doubles, Build to Ten). However, in this study, trained cross-age tutors were used for a four week period. Subjects were chosen from a mixed-ability Grade One class. Six high-ability tutors were selected from a Grade Six class and trained to use a new tutoring structure called the M.R.A.R. model, that was developed as part of this study to teach thinking strategies in addition. Tutor-student talk was recorded and used to develop understandings of the role of verbal interactions in the tutoring environment.

3.2 The M. R. A. R. Tutoring Model.

In schools teachers use tutoring according to the needs of the children involved. Some programs are loosely organised around a content area such as paired reading: others have a tightly structured sequence of learning experiences and materials. Topping (1987) and Goodlad and Hirst (1989) found that one of the most important determinants of the success of tutoring programs was an appropriate structure that was placed on the tutors and the students. The Pause, Prompt, Praise technique (Glynn 1985) is a good example of a structure that was imposed in a reading context.

Frager and Stern (1970) used 11 year old tutors to teach kindergarten children pre-reading skills. The five steps in the process were defining goals, defining obstacles, specifying alternatives, identifying consequences of specific alternatives, and making selections according to alternatives. These tutoring structures were developed to suit a particular need. Frager and Stone's model was aimed at providing a variety of different reading strategies to the tutees and to share the consequences of these choices. In this study the tutoring structure was used to develop alternatives and possibilities in students' addition strategies.

The M.R.A.R. model was developed to provide a structure for tutors to teach students three simple addition strategies. Beyer (1988) lists seven successful techniques that could be used in the direct instruction of thinking strategies; modelling, metacognitive reflection, use of procedural checklists, rehearsal, use of graphic organisers, cuing and labelling. Some of these techniques can be used in the tutoring environment. At a most basic level the tutor must show the student how to perform the skill. In tutoring modelling of the desired behaviour is a natural starting point. It is important that any instructional mode that aims to teach children new thinking strategies should firstly be based on the modelling of more capable and mature thinkers. History records Ancient Greeks as using modelling or "mimesis" as a deliberate instructional mode. Modelling has become the most fundamental technique in the teaching and learning process. Older peers model new skills such as kicking a ball, or writing a letter and allow the learner to imitate such behaviours. Modelling has been described as the " acquiring of skills, beliefs, and novel behaviours" (Rosenthal & Zimmerman, 1978).

Schunk (1987) examined the role of peer models and children's resultant behaviour change. Schunk found that there were problems modelling to very young children. These problems were developmental. Younger children had difficulty in maintaining their attention on the modelled events for satisfactory amounts of time. Bandura (1986) observed that younger children had difficulty sorting relevant and irrelevant cues and that they lacked an extensive knowledge base.

Bandura's (1986) main contribution to understandings about modelling was based on the idea that people learn by observing the behaviour of others in their social environment. This occurs through the established members of social environments modelling appropriate behaviours. According to Bandura (1986) social learning through modelling involves four sub processes. *Attention* allows environmental events to be perceived. *Retention* involves the coding, transformation and storage of information into memory. Retention also includes cognitively rehearsing information which is particularly important if students are to use new strategies as a part of their cognitive organisation. *Production* is the translation of visual and symbolic conceptions (to modelled events) into overt behaviour. *Motivation*al inducements for action can result from direct, vicarious and self produced experiences

Meichenbaum (1977) used modelling extensively in his Cognitive Behaviour Management (C.B.M.) programs. C.B.M. aimed to teach students *how* to think, not *what* to think. Meichenbaum's aim was to teach self-coping strategies that were used to modify the behaviours of a diverse range of subjects. These included impulsive children, schizophrenics and children with uncontrollable phobias. Models were used to develop self-coping verbalisations that were firstly taught as overt verbalisations and gradually became part of subjects' internal speech.

A great deal of importance has been attached to the significance of modelling in the teaching of thinking strategies (Pressley, Borkowski & Schneider 1987; Whimbey & Lochhead, 1982). Schunk and Hanson (1985) demonstrated that peer models enhanced self-efficacy for the learning of cognitive skills better than adults could. In the teaching of thinking strategies it is the modelling of the competent adult, or tutor, that enables the learner to see inside the mind of competent learners. So much of the craft of a capable learner is hidden and unknown to the novice child without the teacher making each step explicit. Ambiguity is reduced for the student by the more capable model. The model provides options for the student by revealing what choices are available at each step and justifies why each option was selected. This develops an understanding of the use of different strategies.

Modelling of efficient repair strategies, such as re-reading and backtracking, facilitates greater understanding and confidence in the learner. Awareness develops among novices that competent learners are only competent because they have made errors, and that they have learnt from them. Clearly as Bandura suggests other behaviours are modelled by competent thinkers. Skills and habits that may seem peripheral are modelled. Learning materials are organised, reminders are written to prompt attention. Students become aware how concentration is focussed. The manner of the competent strategy user also becomes explicit. A calm controlled approach holds considerable advantages over anxious spasmodic attempts. Perhaps most importantly the novice becomes aware that good thinking is hard work. Van Lehn (1986 p. 133) found that modelling was central to mathematical understanding when he stated "arithmetic is learned by induction-the generalisation and integration of examples". Modelling is the most natural instructional method for making such examples meaningful.

Suitable models reveal their skills and knowledge through language and demonstration. A great deal of research has focussed on the Think-Aloud protocol that was developed by researchers who saw the value in revealing capable students' cognitive processes to other learners. Research indicates considerable benefits to learning disabled students (Harris, 1986) and impulsive children (Kendall & Braswell, 1982) from this approach. Davey and Porter (1982) found that Think-Aloud techniques facilitated more effective reading comprehension. In Mathematics, Schoenfeld (1985) reported that children's problem solving skills at a junior high school level improved dramatically after intervention using Think-Aloud methods. In a tutoring environment students make their thoughts and perceptions known as part of the task that they are engaged in. No artificial use of overt verbalisations is needed. A more natural interchange takes place.

Rehearsal was chosen as the second part of the M.R.A.R. model as a check for both tutor and student of the student's understanding of the thinking strategy that had been modelled. Rehearsal enables students to structure the task into a workable form for themselves. Rehearsal in many ways can be more important for the tutor than the student. By rehearsing, the student can reveal to the tutor the pitfalls and problems involved in their thinking. In the tutoring environment the tutor may take into account the idiosyncrasies of their student by anticipating the mistakes that could occur.

Checking for understanding is vital part of the tutoring process. In the context of scaffolding and Vygotsky's (1978) zone of proximal development, tutors need to know which parts of the task students have mastered and which parts require extra support. Therefore it was decided to include an apply part to the model where the student was required to work on the task relatively unassisted.

The Apply part of the model was aimed at developing tutors' understandings of what the students could complete independently and therefore strengthened tutors' understanding of their students' strengths and weaknesses. It was stressed during tutor training that the Apply part of the model was time in which the student independently completed the task and the tutor was only to observe what was happening. Tutors could remind students' of the steps. Prompting or the completion of any part of the task was discouraged.

In teaching the thinking skill the tutors could model the thinking strategy, allow the students to rehearse the new skill aloud and finally could check the understanding of the students by encouraging self-reflection. At some stage students need to rehearse the skill with the support of the tutors to make their thinking clear.

The final step of the M.R.A.R. model was developed in response to research that has revealed that students are not efficient at discovering metacognitive information on their own (Pressley, Levin & Ghatala, 1984). The Reflect stage aimed to improve cognitive monitoring by students so that they would understand the advantages and drawbacks of their strategy selections. Metacognition broadly involves the understanding individuals have of their own strategies and thinking processes and their ability to monitor and regulate these routines. Metacognitive reflection appears to hold considerable benefits in developing children's understandings of the learning strategies and generalisation of these strategies to other contexts. If students are to use strategies broadly and appropriately students need to know when and where they can be used.

Reflection involves analysing and judging past events. Reflective thinking occurs before learning, during learning and after the experience. Baird, Fensman, Gunstone & White (1991) state.

> Enhancing understanding of the nature and process of reflection is fundamental for more purposeful teaching and more meaningful learning. (p. 95)

Reflection develops students' level of consciousness so that they can exert greater control over their thought processes. Procedural problems can be revealed through reflective thought. In the M.R.A.R. model the tutor has a vital role in the questioning of the student by asking "what" and "why" questions. "What" questions will be aimed at provoking children's recall of procedures used. "Why" questions will be involved with the rules of the task.

In the tutoring environment the two-way communication that flows between the partners can involve a rich interplay of ideas that actively facilitates reflective thought.

Wilson and Wing-Jan (1993) argue that teaching that aims to develop reflective thought belongs to a different paradigm of learning that they called the Independent-Reflective. Table 2 highlights the differences between the more traditional forms of teacher directed instruction and the Independent-Reflective paradigm.

Table 2 indicates there are fundamental differences between traditional classroom instruction and the reflective paradigm. Most importantly the reflective paradigm asserts that learning is an active, situation specific, flexible endeavour that encourages the involvement of the student in decision making and goal setting.

Table 2. Two paradigms of Learning: Traditional and Independent-Reflective (Wilson & Wing Jan, 1993 p. 7).

	Traditional	**Independent-Reflective**
Starting Point	knowledge transmission	students' strengths and weaknesses
Purpose	change	develop responsible learners
Role of the learner	passive recipients	active decision maker
Role of the teacher	information giver	facilitator
Indicators of success	change by test scores	ability to apply ideas independently able to plan own goals
Learning	prescriptive	supports risk taking
Environment	teacher directed	co- operative groups
Communication between teacher and learner	teacher corrects errors	two way, positive, regular specific
Questioning strategies	closed questions	open questions
Feedback	teacher determines whether answer is right	encourages/praises
Structure	fixed time and routines	flexible student input

Beaumont (1994) in an eight week pretest-posttest semi-experimental study found that tutoring in reading strategies (sight words, phonics and syllabification) developed metacognitive thought due to this interplay of ideas between tutor and tutee. Beaumont also found that there were fundamental differences between the traditional paradigm of learning and the independent-reflective paradigm developed by Wilson and Wing-Jan (1993). Table 3 demonstrates that tutoring can provide a reflective environment that encourages the development of shared understandings of learning strategies.

Table 3 links the reflective paradigm and peer tutoring. It explains how peer tutoring seeks to engage learners actively in the learning process by giving tutees a measure of control. Tutors provide guidance. Communication is two way through open questioning that engages the learner in reflective thought. The flexibility of the teaching relationship remains a crucial aspect in the whole process.

Table 3. The Independent-Reflective Paradigm of Learning and Tutoring developed from Two Paradigms of Learning: Traditional and Independent-Reflective, Wilson & Wing Jan, 1993 p. 7 (Beaumont, 1994).

	Independent-Reflective	**Peer Tutoring**
Starting Point	student's strengths and weaknesses	Builds on students' knowledge. Tutees begin from their level not a predetermined grade or mark
Purpose	develop responsible learners	Children choose materials, activities. Tutors/Tutees manage time
Role of the learner	active decision maker	Learner engages actively in learning. Shared decision making
Role of the teacher	facilitator	Tutors facilitate/organise a flexible framework. Equality in learning
Indicators of success	ability to apply ideas independently able to plan own goals	Self assessment-tutees set own goals
Learning	supports risk taking	Supportive one to one risk taking environment
Environment	co- operative groups	One to one sharing
Communication between teacher and learner	two way, positive, regular specific	Reflective positive interchange of ideas Student specific
Questioning strategies	open questions	Encouragement to consider possibilities. Stimulating
Feedback	encourages/praises	Positive active reinforcement
Structure	flexible student input	Negotiation of activity time

Langer and Applebee (1986) identified five essential components of effective instruction: ownership, appropriateness, structure, collaboration and control. These provide a framework through which the strengths of tutoring can be examined and discussed. Ownership refers to the sense of purpose, personal goals and products available within the instructional mode. In the tutoring environment ownership of the learning experience is of fundamental importance. The tutor modifies the tutoring program to assist the student make meaning of the content. Perhaps the greatest strength of tutoring as an instructional mode is that it develops students at their appropriate level (Bloom, 1976). Learning is individualised: tutors modify instruction to suit the needs and learning styles of their students. Tutees are closely monitored and more time is spent on task than in regular classrooms (Goodlad & Hirst, 1989). Conversely, in traditional classrooms teachers battle to meet the needs of perhaps thirty different students.

Learning needs to be intertwined in activities that both recontextualize and provide a structure to the experiences. Collaboration is the hallmark of tutoring. People working together to develop *shared* understandings rather than the imposition of alien concepts and processes. Langer and Applebee (1986) stress that this collaboration is mutually informative. Research has shown conclusively the benefits of tutoring to both the student *and* the tutor (Cohen et al. 1982). Perhaps the most wide-arching goal of instruction is to develop lifelong learners who will take responsibility for their own learning. Tutors model appropriate behaviour for their partners. In short tutors show tutees how to learn. Control is released slowly and according to the tutee's learning style and strengths and weaknesses. Regular and responsive feedback occurs which is specific to the individual student's needs.

The M.R.A.R. tutoring model was developed to harness the advantages of tutoring in the development of metacognitive thought and empowerment in the learning process. Students develop ownership of their own learning and as Table 3 suggests such ownership is active and responsible. If students are to actively construct knowledge of learning strategies into their own mental models instruction must take into account the way children acquire strategic knowledge. Such knowledge needs to be acquired as naturally as possible in terms that do not threaten or hinder the active sharing of strategic perspectives. Therefore tutoring programs with a structure that mirrors this natural interchange of ideas and involves clear, concise training of tutors with suitable instructional materials seems to hold considerable benefits in the teaching of thinking strategies in elementary schools and to broader populations.

3.3 Research Methods and Procedure

This research was undertaken as a part of a school tutoring project in Term II in 1995 in a Tasmanian primary school. A pretest posttest semi-experimental model was used. The procedures used did not markedly depart from normal classroom teaching procedures. Tutoring was included in the daily routines of students.

3.3.1. Subject Selection.

Ethical clearance was obtained from the University of Tasmania Human Experimentation Ethics Committee and the Department of Education and the Arts. Permission was obtained in a letter sent home to parents (Appendix 1). All students mentioned in this study have had their names changed to maintain their anonymity. The tutored subjects involved in the study were members of a mixed-ability Grade One class in a semi-rural community thirty-five kilometres from the capital city of Tasmania, Hobart. Initially all twenty seven children in the class were informally questioned about strategies used in addition. From this class group six children were selected to take part in the tutoring experiment. The ages of these subjects varied from 6.4 to 7.1 years. Pretesting confirmed that all subjects had a sound conceptual understanding of addition. This was demonstrated when subjects completed a fifty-item addition test in unlimited time, using concrete materials if needed. The subjects were selected for tutoring due to the differences that existed in their addition methods. Four were using thinking strategies ('min' model) and two were mostly reliant on counting methods.

3.3.2 Tutor Selection

Six tutors were selected from a high-ability Grade 6 Mathematics class. Two criteria were used to select tutors. Tutors had to demonstrate their competence in number work. Secondly they had to demonstrate a high level of interpersonal skills. Both sexes were equally represented.

3.3.3 Pretest Instruments and Procedure

Proficiency in addition was measured through an oral and written test. A ten-item Oral Report Test (Appendix 2) was used to ascertain which thinking strategies, if any, students were using. Question One ($3 + 1 = \square$) was selected to test for recall of simple addition sums involving one. Question Two ($10 + 5 = \square$) tested students' ability to count on from ten when ten was the first addend. Question Three ($6 + 6 = \square$) was a double. This was included to ascertain whether students could recall the doubles facts. Question

Four (2 + 9 =□) tested students' sophistication in the use of the 'min' model. Question Five (4 + 6 =□) tested use of the Near Doubles strategy. Students were expected to double the four and add on two. Question Six (7 + 3 =□) tested students' ability to use the 'min' model. In this question the larger addend was first. Question Seven (8 + 6 =□) tested the Near Doubles, in this question the larger addend was first. Question Eight (7 + 10 =□) children's ability to count on from ten was ascertained. Question Nine (5 + 5 =□) was another double. Question Ten (8 + 4 =□) was included to ascertain if any students were using the Build to Ten strategy. Only one Build to Ten question was included because classroom observation had revealed that no students used this strategy. Throughout the Oral Test the researcher sat next to the subjects and asked them how they had worked out particular answers.

The timed Written Test (Appendix 3) was used to measure which methods children used when speed of response was important. It was also used as an indication of proficiency in addition. The Written Pretest consisted of two pages of sums that included all of the possible addition combinations to ten. The first page contained fifty-five sums and the second forty-five. The order of the magnitude of the digits was randomised. The subjects were given a time limit of five minutes to answer as many questions as they could. Sheet two was given to the subjects if they finished sheet one.

3.3.4 Pretest Administration

All pretests were administered in the same way. Subjects were withdrawn individually to the school library. Students were told they were going to be videotaped doing some sums and answering some questions. All subjects were instructed as follows:

"We are going to do some adding sums today. You will work down the sheet and I will sit here and watch you doing them. You can work them out any way you want to; try to get the best answer you can. You don't have to use the same way every time. You might see me writing down some things on my paper. I'm interested in finding out how people of your age add up, so after you work one of these out I might ask you how you worked out the sum. I want you to remember how you did them in your head."

After each question was completed the researcher asked the child "How did you do that one?" or "What happened there?" Clarification was sought if the response was uncertain or confusing. Often children would volunteer information without being asked. Children were verbally encouraged and given ticks next to correct problems. Subjects' responses and their manipulations of counting blocks were videotaped. These responses were transcribed and have been placed in Appendix 5. Conventions of Transcriptions are described in Appendix 4.

The second part of the pretest was a Written Test. Subjects were given five minutes to complete as much of the Written Pretest as they could. Instructions were given as follows:

"On these sheets there are lots of add up sums and I want you to do as many as you can in five minutes. No-one could finish all of these sums in five minutes! Just do the best you can. You can use whatever you like to do the sums and you don't have to use the same way every sum. Ready..go!"

3.4 Tutoring Phase

3.4.1 Introduction

Six high-ability students were selected to tutor six Grade One students of mixed-ability in three addition strategies ('min' model, Near Doubles and Build to Ten) over a four week period. Tutors were trained and were provided with teaching aids. In order for the researcher to gain a fuller understanding of the interplay of language in the tutoring environment tutors were each issued with a portable audio tape recorder and were instructed to tape what was said in the teaching time.

3.4.2 Tutor Training Sessions

Tutor training sessions were conducted with the six tutors over two forty minute sessions that were held three days apart. Session One comprised the introduction of the three addition strategies ('min' model, Near Doubles, and Build to Ten) that were to be taught. Session Two involved revision of the three thinking strategies and instruction in the use of the M. R. A. R. Tutoring Model.

In Session One tutors were first instructed in the teaching points of the 'min' model. All tutors preferred to use the name 'min' so this was used in the tutoring sessions. Initially tutors were instructed in the 'min' model using blocks; then the iconic level sheets in the Tutor Book were shown to the tutors (Appendix 6). Finally abstract operations were demonstrated. In the first step of teaching the 'min' model the tutors were taught to identify the larger addend. Secondly they were taught to reverse the sum if the larger addend was last and thirdly they were instructed to hold the larger addend in their head.

Finally tutors were told to say the larger addend first and then to count on with the tutees. The last step was designed to provide the support at a crucial stage of the 'min' strategy. Observations by the researcher had indicated that Grade One children could identify the larger addend quite reliably. It was the counting on process that was problematic. The child either forget what the larger addend was or, when counting progressed "lost" the initial addend by focussing too much attention on the counting process. Therefore the prompting of the tutors was needed to assist at the initial stage of counting on. The Near Doubles strategy was introduced to the tutors by questioning them on the nine doubles facts. Tutors were then shown how the doubles could be used to solve sums that were one or two away from a doubles fact. Opportunities were given for the tutors to work in pairs on using the strategy. One tutor brought to the group's attention that the students had the choice of two doubles facts. In the example $4 + 5 = \square$ one can double four and add one or double five and subtract one. Tutors were told to encourage the students to choose the smaller double and add. When the tutee was comfortable with the adding method the subtraction could be shown and practised.

The steps shown in the teaching of the Near Doubles strategy were taught as follows. (1) Drill the nine doubles using the doubles cards (Appendix 7) and activity sheets in the Tutor Book (Appendix 6). (2) Use the Near Doubles sheets to identify which Near Doubles fact the sum was near. (3) Using the blocks construct the double using a different colour for each addend. Step 3 was then modified to take into account teaching in the iconic and abstract levels. In the iconic, tutors were encouraged to use the sheets provided on Near Doubles in the Tutor Book. At the abstract level tutors were told to teach the students to identify the smaller addend to recall the double fact for this number and to add on the difference between the smaller addend and the larger number.

The Build to Ten strategy was introduced to the tutors with an egg carton that had two of the partitions removed from it. Children were presented with a problem $8 + 4 = \square$ and asked how they could teach someone to add the numbers up using the egg carton as an aid (after Steinberg, 1985). Most tutors guessed that the method had something to do with ten. The tutors were instructed to teach the Build to Ten strategy in this order. (1) Tutors were told to allow the tutee to count up the ten partitions in the carton. (2) Tutors were instructed to set out a Near Doubles question from the Build to Ten question sheet in the Tutor's Book (eg. 9 + 5 =□). (3) Tutors were instructed to count the blocks from the larger addend into the spaces in the carton. (4) Tutors were to add any blocks into the spaces from the smaller addend. (5) Tutors were then told to check that the tutees knew that there were ten in the carton *without* counting. (6) Finally tutors were to put the ten together with the blocks remaining (in the example 10 + 4 = 14). The abstract process was demonstrated by showing the tutors how to find how many of the smaller addend was needed to increase the larger addend to ten. What was left of the smaller addend was then added to ten. At the end of the process tutors were instructed to encourage students to say that 10 + 4 = 9 + 5. After the three strategies tutors were introduced to the strategies cue card (Appendix 8) that was placed in the front cover of the Tutor Record Book. To conclude Session One tutors were given an opportunity to revise the strategies.

Session Two began with a revision of the three strategies and practise in selecting the most appropriate strategy. Tutors were shown instances where two strategies could be used. When this situation arose they were encouraged to let the tutee decide which strategy was the most appropriate for the situation. The M.R.A.R. strategy teaching method was then demonstrated to the tutors. Following this they were shown how they could start with the 'min' model (at the concrete level using blocks) to model, rehearse, apply and reflect. Similarly tutors were shown the Near Doubles and Build to Ten strategies. Finally the researcher showed the tutors the Tutor Record Book. This included concrete, iconic and abstract level activities. Tutors were also shown how to record what they had covered in each session on the Tutor Record Sheet (Appendix 9).

3.5 Recording of Student-Tutor Talk

Tutor-student conversations were recorded by the tutors. Each tutor was given a small portable recorder to record the fifteen minutes of teaching that occurred in each session. Scaffolded instruction is based on the interchange of ideas and the tutor providing support for the student during the learning process. The intention of the researcher was to examine this interplay and to assess which aspects may be useful in strategy teaching. The researcher also aimed to understand more fully the methods used by tutors to correct student misconceptions. It was expected that some form of protocol would have to be developed to analyse the data. This protocol is explained fully in Chapter 4 which also presents results of the Oral and Written tests.

3.6 Design of the Tutoring Program

The tutoring sessions were run as part of the normal school program. Subjects were tutored together every school day at the same time for four weeks. Two venues were used: the school library and the staff room. Despite absences and illnesses each pair completed twenty sessions. The program was divided into four parts. Week One was for tutoring in the 'min' model. Week Two was used to teach the Near Doubles strategy. Week Three was Build to Ten. In the last week tutors revised the three strategies and coached students in the appropriate use of each strategy. Each session consisted of fifteen minutes of tutoring the strategies and fifteen minutes of games and activities. These mathematical games and activities included; drill and practise activities on The Little Professor™ (a hand held drill and practice computer assisted learning game), drill and practice games on a B.B.C. Compact computer, dice games, addition flashcards, Tutor Systems Dominoes™, Near Doubles snap (a game developed from the Near Doubles cards, Appendix 7) and appropriate teacher prepared addition sheets from the Tutor Record Book. The researcher was present during each session. All tutors rewarded subjects with stickers at the end of each lesson. The amount of stickers allocated varied between the tutors

3.7 The Post Test situation

Subjects were retested using the same instruments in the week following the tutoring experiment. The same procedure as the Pretest was followed. Parents were contacted through the school newsletter and two contacted the researcher for information on their child's progress in the program.

CHAPTER 4

RESULTS

4.1 Introduction

As with any examination of data that involves personal interactions results were rich, varied and difficult to quantify. The results chapter of this paper is divided into three sections. The first section presents the results of the Oral and Written Pretests. Section Two presents the results of the Oral and Written Posttests. Section three reports on the recordings of the tutored sessions. Taping of the scaffolds led to the development of a Tutor Scaffolds Protocol that facilitated a meaningful presentation and analysis of tutor-student conversations.

4.2 Pretest Results: Summary

In the Oral Pretest all subjects demonstrated their understanding of the addition process (Appendix 5). Blocks and finger counting were used consistently by most subjects. Mark, Sandra, Tony and Cassandra demonstrated limited use of the 'min' model. These students all reliably counted on from ten irrespective of the position of the larger addend. The six subjects generally used recall of number facts when the problem involved one, two or three and when facts could be easily remembered, i.e., doubles and addition facts involving ten. The way subjects undertook the addition process was quite similar. Initially in both pretests children would sit and attempt to recall the answer. This involved looking intently at the problem and for one subject (Tony) saying the problem out loud. If an answer could not be retrieved subjects moved into a counting method which was invariably finger counting or counting all with the blocks. Children did not change from one counting method during the Pretest, i.e. if they started with blocks they continued to use them throughout the test. Table 4 explains the percentage of methods of addition and use of the 'min' model recorded in the Oral Pretest. Subjects were presumed to have retrieved answers if they responded quickly and/or commented that they knew the answer or said; "It just came into my head!"

TABLE 4. Subjects' Percentage of Counting Methods in Oral Report Pretest

Subject	Retrieval	Decomposition	Count all (Blocks)	Count all (Fingers)	Evidence of counting on	Use of 'min' model
Cassandra	30	0	0	70	•	•
Emma	10	0	30	60		
Jenny	10	0	40*	50*		
Mark	40	0	40	20	•	•
Sandra	40	10	10	40	•	•
Tony	20	0	50	30	•	•

* Jenny as explained in the individual subject discussion used a combination of blocks and finger counting.

- Subjects demonstrated to the researcher that they were successfully using the strategy.

Pretest results indicate a spread of ability in the six subjects. Tony, Sandra and Mark demonstrated more mature addition strategies. Sandra and Mark relied on retrieval for many of their answers, and used the 'min' model accurately. Although Tony used blocks he demonstrated a working knowledge of the 'min' model (Appendix 5 Oral Pretest Transcripts: Tony Lines 10-13). Emma and Jenny relied heavily on counting with their fingers and blocks and only used retrieval in very simple problems involving one. Cassandra appeared to be in a transient stage between the two groups that have been described. Although she could use the 'min' model Cassandra used counting with her fingers regularly. She did not use the blocks at all.

Table 5 records the subjects' Written Pretest scores. Five of the subjects (Cassandra, Emma, Mark, Sandra and Tony) recorded totals that were very similar to each other, despite their use of different methods. Jenny switched from blocks in the Oral Pretest to finger counting in the Written Pretest.

TABLE 5. Subjects' Written Pretest Scores

Subject	Written PreTest Score
Cassandra	21
Emma	20
Jenny	12
Mark	20
Sandra	23
Tony	22

4.3 Posttest Results

After the tutoring program was completed students were retested using the same instruments. The Oral Posttest provided data on the changes that had occurred in students' strategy choices whilst the Written Posttest revealed changes in speed and proficiency in addition. Table 6 shows students' use of the three taught strategies in the Oral Posttest. All students were now using the 'min' model. Two students, Sandra and

Tony, were using all three strategies. Tony still needed concrete aids to complete the Build to Ten question in the Oral Posttest. Three students (Emma, Jenny and Mark) showed no evidence of any use of the Near Doubles strategy.

TABLE 6. Subjects' Strategy use in the Oral Posttest

Student	Min Model	Near Doubles	Build to Ten
Cassandra	•	•	
Emma	•		
Jenny	•		
Mark	•		•
Sandra	•	•	•
Tony	•	•	• *

* Tony used the Build to Ten strategy at a concrete level.
- Students demonstrated use of strategy.

All students improved their Written Pretest results. Table 7 compares the Written Pretest and Posttest scores.

TABLE 7. Subjects' Written Pretest and Posttest Scores

Subject	Pretest Written Test Score	Posttest Written Test Score	Difference
Cassandra	21	49	28
Emma	20	26	6
Jenny	12	42	30
Mark	20	57	37
Sandra	23	61	38
Tony	22	32	10

The mean improvement of all students was 25 marks. Two students improved dramatically from the Pretest: Sandra improved by 38 marks and Mark bettered his

Pretest score by 37. Jenny made considerable progress (30). Her initial score was the lowest of all the students. Tony (10) and Emma (6) improved marginally from their Written Pretest scores.

4.4 Results of Student-Tutor Recordings

4.4.1 Introduction

Throughout the literature on scaffolded instruction consideration is given to the explanation of the scaffolding process as a whole without attention to specific examples of scaffolds within the tutoring environment. Much has been made of the rich interplay of language and in the construction of knowledge together during the scaffolding process (Wells & Chang-Wells, 1992). Although scaffolds do vary according to the instructional context little attempt has been made to categorise them in an attempt to understand the tutoring process more fully. Niedermeyer (1970) developed a Tutor Observation Scale that focussed on the observed behaviours of tutored pairs. Trained observers sat near to tutors and categorised the behaviour of the student and the tutor as follows.

1. *Student gives correct response*

Student responds correctly to stimulus, or corrects himself spontaneously upon first presentation.

2. *Tutor gives praise*

Tutor makes a positive approving statement to student following the correct response.

3. *Student gives incorrect response*

Student responds incorrectly to stimulus upon first presentation.

4. *Tutor corrects student*

Tutor tells student correct response after student answers incorrectly.

5. *Tutor repeats stimulus*

After correcting an incorrect response, tutor presents same stimulus again.

6. *Tutor prompts*

When student does not respond or gives incorrect response, tutor gives hint or clue as to the correct response.

7. *Tutor gives negative reinforcement*

Tutor verbally disapproves of student's behaviour.

The Tutor Observation Scale is of limited value due to its concentration on the *observed* behaviour of the tutor and tutee. Recordings were made from a distance away and only recorded what could be seen. Little emphasis or importance was placed on the interplay of language or on the intervention styles of the tutors. It is the intervention of the tutors that is of interest in this study.

4.4.2 Tutor Scaffolds Protocol

Approximately thirty-seven hours of tutor-student talk was recorded during the experiment. Assessment of the audio tapes led to the development of a Tutoring Scaffolds Protocol. The protocol was developed to quantify the different scaffolds provided by the tutors (Appendix 10). Scaffolds were defined and categorised by the researcher using the protocol. The scaffolds were categorised according to the definitions provided below.

Operating Concrete Materials:

Tutor operates concrete materials whilst instructing the student.

Providing concrete materials:

Tutor provides concrete materials for student.

Returning to concrete materials:

After working at an iconic or abstract level the tutor returns the student onto concrete aids.

Providing visual representations:

Tutor draws a picture or diagram to assist student's understanding.

Reminding of steps:

Tutor reminds student *as* he/she is working.

Breaking into simple steps:

Tutor breaks a step into smaller sub-skill(s) or parts.

Backtracking:

Tutor goes back over what has been done and identifies error(s).

Restating:

Tutor provides the same stimuli *after* a problem has been completed.

Prompting:

Tutor works through all the steps in a strategy and leaves the tutee to complete a one word answer or phrase that completes the task.

Rephrasing:

Tutor puts a question or a step another way *after* the student has completed a sum.

Highlighting similarities:

Tutor draws student's attention to other sums that have been completed with a similar answer or process.

Decomposition into a known fact:

Tutor uses blocks to decompose sum into known problem.

Using Terminology as a prompt and in general dialogue:

Tutors use terms such as Count On, Build to Ten, Near Doubles, to prompt strategy use and labelling differing behaviours.

Organisational scaffolds:

Tutor tells student what is hoped to be achieved in a session.

Revising:

Tutor revises the previous session.

Directing attention:

Tutor directs student's attention to the task.

Limiting task:

Tutor narrows task down to one step of a problem.

Metacognitive thought:

Tutor encourages student to think about his/her thinking.

Completion of the whole task:

Tutor completes the task from start to finish.

4.4.3 The Tutor Scaffolds Protocol and the Functions of Tutoring

Wood, Bruner and Ross (1976) explained the role of tutoring in problem solving by categorising the functions of tutors. Scaffolds identified in this tutoring program from the protocol were placed within the framework provided by Wood, Bruner and

Ross (1976). This enabled a clearer examination of the scaffolding within the tutoring process to be made. The six tutoring functions of Wood, Bruner and Ross (1976) are numbered and are double underlined. The scaffolds identified in this study are in bold type. Explanations are provided under each heading. Where appropriate transcripts are provided from the audio recordings. These headings are in bold italic type. Conventions of Transcription are provided in Appendix 4.

1. Recruitment.

In a school context students take part in activities without the need to enlist the tutees active support. Recruitment was important in the tutored pairs understandings of why they had been selected to take part in the program. There was considerable kudos for all children to be involved. The fact that they (tutors and students) had been chosen to take part developed children's sense of purpose. Individual materials were provided and sessions were taped.

2. Reduction in degrees of freedom.

These were what have been called structural scaffolds that provide clear boundaries to the learning environment.

Organisational scaffolds

Tutor tells student of future directions in instruction. Some tutors told students what they hoped to achieve in a session. These were used to provide the tutor with a purpose and overview.

Transcript: Betty 2a (078) Explaining what is going to happen in the session.

(Context: Betty gave Mark a few examples to complete and then discussed the days session.)

Tutor: O.K.! When you do that kind of sum. We call it the 'min' model. We are going to do lots of 'min' model work today and then we will do the other ones.

Providing concrete materials.

Tutor provides materials for student to work with.

Operating Concrete Materials

Tutor moves and places concrete materials whilst instructing student.

Returning to concrete materials

After working at an iconic or abstract level the tutor redirects the student onto concrete aids.

Transcript: Rhys 2a (249) Returning to concrete level

(Context: After experiencing some problems with teaching the doubles Rhys redirected Cassandra back to the concrete level.)

Tutor: Eight plus eight does not equal seventeen!

Student: Err!

Tutor: (sighs) We are going to have to do some work on this! (long pause) Aren't we? (Rattling of blocks as they are reintroduced.) Um, what about we do nine?, and then ten?

Revising

Tutor revises the previous session.

Transcript: Daniel 1a (124) Reduction in degrees of freedom: Revising previous session.

(Context: The tutor reminded Emma about the 'min' model that they had covered in a previous session and what they had done as a starting point for the next lesson.)

Tutor: O.K. Well.. Yesterday you just practised holding the big number in your head and counting with the smallest one...You did this activity sheet.

Student: Mmm

Tutor: So, if you just want to finish this off?

Student: Yeah!

Tutor: O.K. There you go! Remember REVERSE! them, if you have to three plus four becomes four plus three..so hold four in your head and add on the three. O.K.? (child completes problem) Yeah, That's right! (looking at next problem) You don't have to reverse that one..(student completes the problem)

Tutor: Yeah! That's right!

Limiting task.

Tutor narrows task down to one step of a problem. This was used by the tutors when they perceived that the student was experiencing difficulty or that the initial task was beyond their independent ability. Limiting the task involved two main kinds of scaffolds. At a simple level tutors concentrated on one step or sum. Tutors refined this into developing tutor specific scaffolds limiting the task or by making it more difficult or challenging for their students with the use of speed tests.

3. <u>Direction Maintenance</u>.

Directing attention

Tutor directs student's attention to the task. This involves keeping the student on task by a variety of means. Methods of dealing with poor attention ranged from ignoring irrelevant comments to chastising. Mark chastised Tony for inappropriate behaviour using comments like "Concentrate!" or, "You're not thinking!" Often tutors would refocus students by restating the question. Tutors did not experience any behaviour problems with the students at any stage in the tutoring sessions. All tutors used stickers as a reward for completing sheets successfully or for hard work.

4. Marking critical features

This category was of particular interest in the study. It involved recording the ways tutors marked the important features of the task and what repair scaffolds were used in attempting to change students' responses.

Reminding of steps

Tutor reminds student ***as*** he/she is working.

Transcript: Daniel 2b (036) Reminding as the student is working

(Context: Daniel was reviewing the Near Doubles strategy after some revision of the 'min' model. Emma started to use the 'min' model to work out nine plus eight.)

Tutor: Hold on a minute!..You can do that with sums like one and three and one and two!..But when you get up to sums like .um, .Say eight and nine like here (points at sheet?) What do you do, get the smallest number. Yes! Now eight and eight is?

Student: (long pause) sixteen!

Tutor: So eight and nine is.. SEVENTEEN!

Student: SEVENTEEN!

Breaking into simple steps

Tutor breaks a step into smaller sub-skill(s).

Transcript: Petula 1A (142) Breaking into simple steps

(Context: Petula was trying to teach her student to reverse the larger addend to the beginning of the number sentence and to count on from it. After a series of failures she broke the task into simple steps)

Tutor: You know how I taught you before with the blocks. I had one number **** nine O.K. I've got two piles eight and nine see, and I change them around (Long pause. Tutor moving the blocks around on the mat?) Its nine plus eight, its the same! That's what we will do here with this one. Five plus three is eight and three plus three is eight. You swap them around for me now!

Student: O.K.

Restating

Tutor repeats the same instruction or step **after** a problem has been completed. This occurred commonly in drill work in which the tutor simply asked the question again.

Prompting

Tutor works through all the steps in a strategy and leaves the tutee to complete a one word answer or phrase that completes the task.

Transcript: Rhys 1b (457) Prompting.

(Context: Rhys was teaching the Near Doubles strategy.)

Tutor: Use the Near Doubles! Change the eight! What are you going to change there?

Student: The seven!

Tutor: So, its seven plus seven, plus one is?

Student: (Long pause) Fifteen!

Rephrasing

Tutor puts a question or a step another way **after** the student had completed a sum.

Transcript: Matthew 2a (275) Rephrasing.

(Context: Matthew was becoming frustrated with Tony's insistence on using the Near Doubles at every (often inappropriate) opportunity.

Student: Four plus four is eight!...

Tutor: No! Don't do that!..That takes too long! Work it out in Build to Ten!

Student: Double four!

Tutor: No! Then you have to count on four! Work it out as Build to Ten (emphasises last three words by tapping rhythm of words on desk with pencil).. AND PUT THEM ACROSS!

Student: Milky Way! ..Milky Way!

Tutor: That's it! Now your getting it!

Backtracking

Tutor works back from an incorrect answer to the place where the student made the mistake.

Transcript: Petula 1a (100) Backtracking

Tutor: What have you done there?

Student: That's ten!

Tutor: Err. No. Put out those blocks! You should have ten but you've put out two lots of four.. When you started here you put out four instead of five and when you *** next part you just put out the same (four) again.

Student: Ohh!

Using Terminology as a prompt and in general dialogue

Tutors used terms such as count on, Build to Ten, Near Doubles and Build to Ten to prompt strategy use and labelling differing behaviours.

Transcript: Betty 2a (194) Using Terminology as a prompt.

(Context: Tutors used the names of counting strategies as a prompt for students to remember the steps in the process. In this transcript Betty is asking the Matthew to name the strategy he would use in a particular sum.)

Tutor: Remember all these ways of doing sums? I'm going over these to find out which one you would use. O.K. Allright!..Four plus five?..No!.Which one would you use?..Say it!

Student: NEAR DOUBLES!

Tutor: Good! ..Fourteen plus two? What does it equal?

Student: Sixteen

Tutor: Nine plus six?

Student: Fifteen!

Tutor: Which one would you use here? (9 + 6 =□)

Student: Fifteen!

Tutor: Yep! Fifteen! But! Which one would you use?..Would you use 'min' model, doubles, < some tutors called the nine Doubles facts as doubles> Near Doubles or Build to Ten?

Student: Build to Ten!

Highlighting similarities

Tutor draws student's attention to other sums that have been completed with a similar answer or process.

Transcript: Lara 2b (084) Highlighting Similarities

(Context: Lara was revising the Build to Ten strategy and used a known fact to assist her in demonstrating that two answers were the same)

Tutor: You've got eleven and six, you take one off the eleven. What does that become? And you take that one and put it on the six and that becomes seven...and that one's ten. So it's ten plus seven...seventeen! and ten plus seven is the same as eleven plus six..isn't it?

Student: Seventeen!

Tutor: And five and twelve and four and thirteen!

Metacognitive thought.

Tutor encourages student to think about their thinking.

Transcript: Matthew 2a (072) Maintaining metacognitive thought

(Context: Matthew was trying to get Mark to tell him how he was doing Build to Ten.)

Tutor: Do it in your head, but tell me what you're doing..No! Concentrate! Tell me HOW!

Student: You just count on in your head!

Tutor: No! I don't want you to count on...concentrate! There's a quicker method!

Student: Err!

Tutor: You can do it faster! O.K!

5. Frustration control.

Tutors provided an array of scaffolds that maintained students' concentration during the sessions and therefore controlling their frustration. Frustration did not prove to be a significant problem. The structure of the program allowed tutors to choose the order in which the tutoring and the games were completed. On some occasions the tutors asked the students what they would like to do first. Additionally the use of stickers by the tutors curbed the frustration of the students. Tutors decided to award stickers for good work and students worked hard to achieve their stickers for the session. The frustration level of the students was very low. This was due to the tutoring partner being available to assist at a moments notice.

6. Demonstration.

Providing visual representations

Tutor draws a picture or diagram to assist student's understanding.

Transcript: Petula: 1A :(248) Demonstration: Providing visual interpretations of operation.

(Context: Petula was introducing the doubles to Jenny and after having no success with drill she struck on an idea to visually represent the situation.)

Tutor: Three and three?

Student: Six!

Tutor: O.K., Good! I'm going to set these up on the floor.. So that it looks like a pyramid. So you go with two and two like this! (manipulating blocks as she speaks into pyramid shape) Three and three? I don't think I've got enough blocks!(muttered) Four and four? Shivers! (Drops blocks from container onto mat).....OK, so we have four and four there. See how its forming a shape? How it goes out?

Student: Yeah!

Decomposition into a known fact

Tutor uses blocks to decompose sum into known problem.

Completion of the whole task

Tutor completes the task from start to finish. It involves demonstration only.

4.5 Results of the Tutor Scaffolds Protocol

4.5.1 Introduction

The Tutoring Scaffolds Protocol provided data on the scaffolds provided during the four weeks of the project. The scaffolds that have been listed in the results are the scaffolds that were identified from the oral recordings of the tapes. Scaffolds were collated and have been placed in Appendix 11.

4.5.2 Tutor 1: Daniel

Daniel provided many scaffolds to his tutor in the sessions. Reminding of steps (71), limiting the task (60) and directing attention (57) and restating proved to be the most commonly used scaffolds. Relating counting materials to children's interest level and decomposition were not used at all. Restating the task into a simpler number sentence (1), providing visual representations (1), completion of the whole task (1), providing concrete materials (5), using terminology (5) and organisational scaffolds were seldom used. Daniel used three hundred and ninety scaffolds in total.

4.5.3 Tutor 2: Petula

Petula provided many different scaffolds for her students Jenny (Appendix 11). Reminding (63), restating (62), and prompting (55) were used most often. Operating concrete materials (35), directing attention (32) and limiting the task (32) were provided moderately. Petula did not use highlighting similarities (3) and decomposition of the problem into a known fact (3) as regularly as some of the other tutors. Four hundred and twenty three scaffolds were used over the four week program.

4.5.4 Tutor 3: Betty

Betty used the reminding of steps (48), prompting (29) and metacognitive scaffolds the most with her student Mark. Many scaffolds were not used at all. These included; relating counting materials to children's interest level, returning to concrete materials, providing visual representations, highlighting similarities, restating the task into a simple number sentence and completion of the whole task. Two hundred and thirteen categorised scaffolds were used during the tutoring period.

4.5.5 Tutor 4: Lara

Reminding of steps was the most used scaffold (32). Metacognitive thought (20), prompting (19), directing attention (18) and providing concrete materials (11) were the other major scaffolds used. Seven kinds of scaffolds were not used at all. These were relating counting materials to children's interest level, returning to concrete materials, providing visual representations, breaking into simple steps, restating the task into a simple number sentence, organisational scaffolds and revising. A total of one hundred and thirty nine categorised scaffolds were used.

4.5.6 Tutor 5: Matthew

Four main scaffolds dominated Matthew's tutoring. Reminding of steps (42) was used the most. Other major scaffolds were using terminology in teaching (41), directing attention (36) and limiting the task (33). Six scaffolds were not used; relating counting material to children's interest level, providing visual representations, highlighting similarities, decomposition of the problem into a known fact, organisational scaffolds and completion of the whole task. Matthew used a total of two hundred and thirty scaffolds.

4.5.7 Tutor 6: Rhys

The only scaffold not used by Rhys was relating the counting materials to children's interest level. Directing attention (43) and reminding were used the most (42). Other major scaffolds used were using terminology in teaching (35), prompting (30) and restating (26). A total of three hundred and twenty nine scaffolds were used.

Data collected from Oral and Written tests revealed changes in the subjects' strategy use. The Tutor Scaffolds Protocol recorded the methods tutors used to teach their students. These results will be discussed in the next chapter.

CHAPTER 5

DISCUSSION AND CONCLUSIONS

5.1 Summary

This study supports earlier research that found that cross-age tutoring is an effective instructional mode for the teaching of thinking strategies in addition (Johnson & Bailey, 1974). Fundamental changes occurred in subjects' strategy use. Subjects who demonstrated an understanding of the 'min' model in the Oral Pretest benefited the most from tutoring. Subjects who did not use thinking strategies in the Oral Pretest did not use the strategies that they developed during tutoring appropriately.

Although the M.R.A.R. model proved to be an effective tutoring model most tutors changed the model to suit their own purposes. The Rehearse part of the model was omitted by the tutors. Therefore a new model for the tutoring of thinking skills is presented later in this chapter.

Detailed analysis of the Tutor Scaffolds Protocol revealed new understandings about scaffolded instruction, in particular the scaffolds tutors used to correct students' misconceptions. *The most important finding of this study is that the repair strategies, as they have been named in this paper, offered by the Grade 6 tutors show a remarkable similarity.* A model will be presented that visually represents the repair scaffolds within the tutoring environment.

The first part of the this chapter will be devoted to discussion of subjects' Pretest results. Next the Posttest results will be discussed and summarised. Part three will discuss the data collected from the Tutor Scaffolds Protocol. This will be followed by a conclusion and some ideas on future directions for research.

5.2 Discussion of Pretest Results: Summary

Although Mark, Sandra, Tony and Cassandra had a working knowledge of the 'min' model, the process of counting with blocks seemed to hinder their development towards more efficient methods. All children used the blocks in a very similar manner. First they would lay out the blocks for the initial addend, then the second, regardless of the size of either. Next they would push the blocks together. All subjects laboured this point. The event seemed to have some significance. It was during this action that Tony and Jenny would say out loud "equals" and on one occasion Jenny said, "makes." Finally all students would count all to calculate the answer. Despite being aware of the value of the first addend, all children, when they used this method insisted on counting all. It seems that a teacher or parent had taught these students this method of adding numbers and had insisted that these steps were exactly the process that was to be used. Students seemed incapable of taking shortcuts or modifying the block counting method to suit themselves. When Tony was asked why he did not count on when he used the blocks he responded: "You don't do these like that!" Clearly Tony understood how to count on and identify the larger addend in the Oral Pretest and yet returned to blocks and the laborious count all process when blocks were available.

The act of using blocks was an important part of Mathematics instruction to these children, so important that it was sometimes used whether it was needed or not. When speed became important in the Written Pretest the more proficient subjects (Mark, Sandra, Tony and Cassandra) apparently used finger counting and recall exclusively. Interestingly accuracy did not suffer. Emma and Jenny relied on counting all with fingers or blocks. The use of finger counting was used quite covertly by the subjects. Fingers were not touched, or tapped on the desk, they were looked at in a downwards glance and accompanied by movements of the fingers that would have been imperceptible to a casual observer. Indeed in Cassandra's case it took the researcher quite a few questions and close observation before finger movement could be detected. Reasons for this behaviour remain unclear. One hypothesis returns us to the children's perceptions of what Mathematics, in particular what adding, "looks like". Many teachers of infants including the class teacher of these children regard the use of fingers as immature and unnecessary and actively dissuade children from using their fingers. It seems that subjects engaged in activities that were consistent with the behaviours of their peers that they observed during normal teacher directed instruction.

5.3 Discussion of Subjects' Pretest Solution Strategies

5.3.1 Subject 1 Sandra

Sandra was competent in single digit addition. She frequently identified the larger addend in the problem, regardless of its position in the sum and counted on from it. When she was using concrete materials Sandra did not return to count all when she had set out the two numbers. In problems involving ten she consistently counted on from ten, reversing the sum if the ten was at the end of the sum where necessary. Sandra had the skills and understandings to use the 'min' model successfully in an abstract way. She demonstrated that she had mental capacity to hold the larger addend in her short term memory counting on the amount of the smaller addend. Her persistence with the use of concrete aids returns us to an earlier theme. When she was asked why this was so, after demonstrating to the researcher her competence in working abstractly, her response was: "You use blocks to do Maths, everyone does!"

In the Written Pretest where the focus was on speed and accuracy Sandra did not use blocks preferring instead to count on in her head, use recall for particular sums, and a dotting process that appeared to equal the number that was being added on. Sandra retrieved a small number of problems, including the easily remembered sums (doubles). Sandra was the only subject who used decomposition in the Pretest (Appendix 5, Pretest Transcripts: Sandra, Lines 16-17). Instead of rebuilding a set of blocks for the sum from scratch Sandra rearranged the blocks by making up the eight by taking one from the seven she had made up for seven plus three. That gave her eight plus two then she added another four onto the two. When the researcher asked what she was doing Sandra responded by pointing at the counters and saying, "That's the same!"

5.3.2 Subject 2 Tony

Tony was the most vocal of all six students in the Pretest phase. He was the only student who vocalised the sum as he was doing it. As the Oral Pretest progressed Tony began to develop the more efficient 'min' model of counting. Initially he set out the first number irrespective of its size and counted all. Later he revealed that numbers can be reversed when adding; this was the case when he added seven and ten. Tony seemed to be aware that numbers could be reversed. He did not reverse them consistently. In the Written Pretest Tony did not use blocks and he skipped problems that he found difficult. These sums had large addends first.

5.3.3 Subject 3 Emma

Emma was the most withdrawn of the subjects and responses to questions were difficult to hear and understand. Count all using fingers and blocks was mainly used. She put out blocks sometimes before really thinking whether she needed them or not. Emma successfully recalled the first sum presented in the Oral Pretest. When she saw a problem that had an answer more than ten she volunteered; "The ones that have got too much for my fingers I use my blocks!" (Appendix 5, Oral Pretest Transcripts: Emma).

5.3.4 Subject 4 Jenny

Jenny used the count all method with her fingers or the blocks for all problems. She did not try to recall even the simplest sums. She became frustrated with sums that had a large initial addend calling them 'hard' sums. On numerous occasions Jenny became unsure of answers and appeared to forget what she was doing. Jenny developed a novel counting method during the Oral Pretest. By combining the use of blocks and fingers she was able to remember ten by placing a block on her little finger (Appendix 5, Pretest Transcripts: Jenny, Line 20). In the Written Test she performed poorly because she chose to use the blocks.

5.3.5 Subject 5 Cassandra

Cassandra relied on the count all method with her fingers to calculate answers. She recalled the first answer. There was evidence of reversal of addends and counting on (Appendix 5, Oral Pretest Transcriptions: Cassandra, Line 6). This reversal was not consistent throughout the Oral Pretest. Cassandra scored twenty-one in the written test and appeared to use finger counting exclusively. At times she appeared to be unsettled by the camera and said that she did not like cameras and photographs.

5.3.6 Subject 6 Mark

Mark demonstrated a basic knowledge of the 'min' model by reversing the larger addend in the second problem and counting on in the Oral Pretest. Although he reversed the numbers in 7 + 10 = □ he did not reverse the addends in the next problem (2 + 9 = □). When he was asked why he did not he responded that he did not want to. In the Written Pretest Mark did not use concrete materials, instead he preferred to use recall or finger counting. Three methods were chosen because Mark appeared to regard faster methods as being the most efficient.

5.4 Discussion of Individual Subjects' Solution Strategies in the Oral Posttest

5.4.1 Subject 1 Sandra

Sandra used all three strategies in the Oral Posttest. She had demonstrated her use of the 'min' model in the Oral Pretest. Although Sandra used all three strategies she used retrieval for facts that were easy for her to remember i.e. doubles (5 + 5 =□) and facts involving ten ((7 + 10=□). Sandra was aware of the advantages the various strategies had in different situations. She showed that she could use two strategies on the same problem (4 + 6=□) if necessary (Appendix 12, Oral Posttest Transcripts: Sandra, Lines 5-9). Why one strategy was chosen over another remains unclear.

5.4.2 Subject 2 Tony

In the Oral Pretest Tony demonstrated a thorough understanding of the 'min' model and Build to Ten. Before the tutoring program his use of the 'min' strategy had been inconsistent despite understanding that addends could be reversed (Appendix 5, Oral Pretest Transcripts: Tony, Lines 6-10). It appears that in the examples where Tony used the 'min' model in the Oral Posttest in Question 4, ($2 + 9 = \square$) and Question 6, ($7 + 3 = \square$) he chose to use the 'min' strategy by ascertaining whether one two or three was an addend in the problem. Tony demonstrated a high level of understanding of the Near Doubles strategy, preferring to double the larger number and subtract than doubling the smaller number and adding (Appendix 12, Oral Posttest Transcripts: Tony, Lines 12-15). Also he showed that he could double the smaller addend when the larger addend that he was doubling became too large for him to work with comfortably (Appendix 12, Oral Posttest Transcripts: Tony, Lines 17-19). He also volunteered that doubles were even (Appendix 12, Oral Posttest Transcripts: Tony, Line 8). Build to Ten was used at the concrete level (Appendix 12, Oral Posttest Transcripts: Tony, Lines 22-28). This was the only way that the tutor demonstrated the Build to Ten method to the student.

One of the most notable observations of the way that Tony completed the Oral Posttest was in his self verbalisation of his thought processes. When faced with reporting the solution Tony would utter the strategy he had been taught as a guide to calculating the answer. He frequently uttered, " Doubles!" or "Count On!" (a name some of the tutors had given the 'min' model) when faced with problems. In the Written Posttest Tony did not use any counting aids; he appeared to use the 'min' model and the Near Doubles strategies. There was no use of Build to Ten. The Written Test Results (Table 7) indicate that Tony improved ten marks between the Pretest and Posttest. The use of thinking strategies at this stage of Tony's development was not the most efficient method. The use of Near Doubles appeared to slow him down in the Written Test. Using simple count on techniques could have been more effective.

5.4.3 Subject 3 Emma

Emma had developed her understandings of the 'min' model. She did not use the model consistently and appropriately. She used counting on from the first addend irrespective of the magnitude of the second addend. The only time she reversed the larger addend was when she was confronted with a problem that involved ten, in the Oral Pretest (Appendix 5, Oral Pretest Transcripts: Emma). Although Emma appeared to know the doubles facts, she did not use the Near Doubles strategy (Appendix 12, Oral Posttest Transcripts: Emma Lines 5-6). Build to Ten was not used in the Posttests. In the Written Posttest Emma relied on counting on and some recall. She did not appear to be using her fingers to assist her.

5.4.4 Subject 4 Jenny

Jenny attempted to use the 'min' model at every opportunity she could. The most important understanding that had developed was that you could reverse the addend so she no longer had to view sums as 'hard' or 'easy'. If they were 'hard' they could be modified (Appendix 12, Oral Posttest Transcripts: Jenny, Line 7). Although she had some knowledge of the doubles she did not attempt to use the Near Doubles strategy. (Appendix 12, Oral Posttest Transcripts: Jenny, Line 5; 10-13). There was no evidence of use of Build to Ten.

The most profound difference in Jenny's simple addition after tutoring was in her use of counting aids. In the Pretest she relied on blocks for almost every sum irrespective of its difficulty. In the Oral Posttest she stated that "she didn't need them" (Appendix 12, Oral Posttest Transcripts: Jenny, Lines 8-9). There was no evidence of any finger counting in the Oral or Written Posttest. In the Written Posttest she used the counting on, 'min' and some recall.

5.4.5 Subject 5 Cassandra

Cassandra's methods in simple addition had altered considerably since the Pretest. Blocks were not used in the Oral or Written Posttest. Cassandra developed the 'min' model during the tutoring phase (Appendix 12, Oral Posttest Transcripts: Cassandra, Lines 7-9). Although she had a good working knowledge of the doubles Cassandra failed to use the Near Doubles strategy preferring to count on (Appendix 12, Oral Posttest Transcripts: Cassandra, Lines 9-14). There was no evidence of any use of Build to Ten. Cassandra did not use any of the three thinking strategies in the written Pretests or the Posttest. Cassandra used the counting on method the most in the Oral Posttest and exclusively in the Written Posttest. In the Written Posttest she appeared to count on from the first addend irrespective of its magnitude. Finger counting was observed in the Oral and Written Posttests indicating this was an important backup method. Despite having all the necessary pre-requisites for effective use of the 'min' model (identifying larger addend, 'holding it in you head' and counting on successfully, the 'min' model was largely ignored.

5.4.6 Subject 6 Mark

Mark used the 'min' model during the Oral Posttest. He did use the 'min' model when it was inappropriate to do so (Appendix 12, Oral Posttest Transcripts: Mark, Lines 13-15). Mark's understandings of adding numbers that relied on ten involved removing the zero on the ten and then replacing the zero with the other addend (Appendix 12, Oral Posttest Transcripts: Mark, Lines 4-6). He appeared to know the doubles facts. Mark did not use the Near Doubles strategy, preferring instead to use the 'min' model (Appendix 12, Oral Posttest Transcripts: Mark, Lines 13-15). Build to Ten was used at an abstract level. Mark chose to Build to Ten in the problem

9 + 2 = □ rather than using the 'min' model (Appendix 12, Oral Posttest Transcripts: Mark, Lines 10-12). Throughout the Oral Posttest Mark scanned other sums and appeared to be searching for other answers that could assist him (Appendix 12, Oral Posttest Transcripts: Mark, Line 15). In the Written Test Mark appeared to count on in problems that he could not recall (doubles and simple facts that involved one two or in a few cases, three). Mark counted on from the first addend irrespective of its size.

5.4.7 Summary of Changes in Counting Methods

Subjects' counting methods changed markedly over the four weeks of the tutoring program. Although blocks were freely available for the Posttest only Tony used them to assist him (Appendix 12, Oral Posttest Transcripts: Tony, Lines 23-28). Some finger counting was evident (Cassandra, Emma and Jenny). This had diminished dramatically since the Oral Pretest. The methods used by subjects in the Oral Posttest and the Written Posttest were different. Although subjects demonstrated their competence in thinking strategies in the Oral Pretest and Posttest few used them in the Written Test. Subjects reverted to counting on when speed was important.

5.5 Discussion of Subjects' Strategy Development.

Before tutoring four students demonstrated varying understandings of the 'min' model (Mark, Sandra, Tony and Cassandra). These students benefited from the tutoring program more than the students who were using counting methods. It was clear that Jenny and Emma did not have the understanding of addition the others had developed. Consequently when these students were taught the 'min' model, i.e. that they could count on from the larger addend irrespective of its position in the number sentence, it was used in *all* addition problems. Even when Jenny and Cassandra had been taught the nine doubles facts by rote and the Near Doubles strategy they did not use it. Instead they preferred to use the 'min' model for problems even when its use was inappropriate (eg. $8 + 7 = \square$). It appeared that these students needed time to use the 'min' model before other strategies were introduced.

More capable students provided more individualised perceptions of strategy acquisition. Sandra had demonstrated a sophisticated understanding of addition in the Pretest. She was the only student who decomposed an addition question in the Oral Pretest. Sandra learnt to use the Near Doubles and Build to Ten strategy. She also showed that she could apply both of these strategies to problems where either strategy could be employed. Sandra's use of retrieval was limited to easy to remember facts (doubles and sums involving ten), and she did not try to recall facts that were quite easy to remember preferring instead to use the 'min' model. Mark, in comparison relied on recall as his main method in addition. As a result although he demonstrated all the prerequisite skills to use the Near Doubles strategy he did not use the strategy. Although Mark enjoyed the tutoring program an important aspect of his perceptions of efficient adding was an ability to complete problems quickly. Any strategy it appeared, that involved more time and effort in its acquisition and operation to Mark was not a useful one. Mark demonstrated a more efficient application of the Build to Ten strategy at an abstract level than Sandra. Although Sandra could Build to Ten the process she used was quite time consuming. For example in the problem $8 + 4 = \square$, Sandra would go through each step in the Build to Ten strategy. Mark however would Build to Ten and then use a method that his tutor had taught him for counting on from ten. The method was to cut off the zero on the ten and put the digit to be added on in the space. There was no counting and the whole process was completed mentally.

Two subjects, Emma and Jenny, demonstrated the behaviours that Cobb (1988) refers to in his observation about the separation of students' understandings and school conceptions of Mathematics. Although these subjects were tutored by very able Grade 6 students they did not use the Near Doubles or Build to Ten strategies. Petula and Daniel were two of the most organised and efficient tutors. Clearly any deficit in students' understanding was not due to poor tutoring. Matthew's approach to tutoring was casual and very informal and yet his subject Tony demonstrated use of all three strategies.

The readiness of students to understand and accept taught strategies into their way of doing Mathematics is a crucial aspect of the teaching of thinking skills. From the data collected it appears that the effective teaching of thinking skills is dependent on the knowledge that students bring to the instructional environment. Another crucial aspect of children's conceptions is the rigidity of their beliefs about mathematics and whether new methods will be given a chance over old established routines. Teachers can influence the acceptance of new ways of working by encouraging Mathematical activities that stress different solution strategies in different situations. The worst thing that can be done is to teach students a "recipe" type approach that leads to a rigid conception of Mathematics that stifles children's understandings.

5.6 Affective Influences on Strategy Development

Children's perceptions of addition strongly influence their application of taught thinking skills. These perceptions reflect children's needs within the learning environment. Adults tend to view children's use of learning strategies according to their own interpretations of the utility of a particular way of thinking. Ease of operation and time efficiency are two characteristics of thinking strategies that adults find particularly important.

Compare this with a child's world and his / her needs. Children may use a strategy for fundamentally different reasons than the rational reasons employed by adults. In the classroom children come under the influence of many factors that adults may regard as peripheral. The affective aspects of learning have been stressed by some (Brown, 1987) as being central to understanding the ways children think and learn. Social interactions, feelings of self worth and physical well-being all interact to affect children's thinking.

This tutoring experiment provided specific examples of affective influences on strategy development. Emma had been tutored by one of the most competent tutors and had demonstrated her understandings of the three strategies and yet she only used the 'min' model in the posttest due to lack of motivation. Daniel spent much of his instructional time encouraging and using stickers to motivate Emma. Similarly Cassandra found the taping of her voice in the tutoring program disconcerting. As a result student-tutor talk was stilted. The lack of open talk appeared to hinder her development of clearer understandings of the Near Doubles and Build to Ten strategies.

5.7 Evaluation of the M.R.A.R. model.

The M.R.A.R. tutoring model that was developed for the teaching of the three thinking strategies underwent considerable change as the program progressed. Tutors modified the tutoring model to suit their own purposes. Although all tutors demonstrated they understood the steps of the M.R.A.R model, once they began tutoring changes were made to the model. Modelling remained as a central part of their tutoring. It was a starting point for the teaching of the three strategies. Tutors used the techniques and teaching aids that had been provided to assist them. Below is an example of a tutor Daniel teaching the Build to Ten strategy to his student Emma. The influence of the tutor in modelling the correct method is highlighted by the tutor's insistence that the student copies what he is doing. The exactness of the whole operation is captured in this transcription.

Daniel 2b (009) Modelling the Build to Ten strategy.

Tutor: Eight plus four?

Student: Eight plus four..four plus four is eight.

Tutor: No!. you shouldn't do that!

Tutor: You can't work that out any of the ways I have shown you can you? You CAN'T say eight then add on four! You can't say four and four is eight! Then add on another four can you?..Because that's too big a number.. Isn't it? So I'm going to show you an easier way to do it! O.K. you'd know what ten plus two is wouldn't you?

Student: Ten plus two?.twelve!

Tutor: Yeah! Good! and eight plus four is twelve as well so, um, I'm going to show a way to work this out. So, we've got eight blocks in there. Eight blocks in there (looking into egg carton?) and four out here (points to desk?). You know that eight plus four is the same as four plus eight, right? So what I'm going to do is take two from here and put it in there so that equals ten so its just ten plus two now.

Student: I've got new sneakers!

Tutor: Good! So tell me what you should do.

Student: You take eight from there put eight in there (pointing to the egg carton?) and add two more.

Tutor: Good! That equals ten and it's easy to do! Good! I'll give you another example. O.K...Eight plus five?

Student: Eight plus five..six, seven, eight (filling up the egg carton together)

Tutor: Eight ..plus one two, three, four, five! What do you think you do there? Eight plus five? There's eight in there and five out here!

Student: Can I put *****

Tutor: O.K. Do that! (Puts two outside blocks in carton). So that equals ten!

Student: Thirteen!

Tutor: Good!

The modelling stage of the M.R.A.R. model was the most fundamental part of the tutoring process. Tutors had to show the students what to do. The techniques used by the tutors during the sessions became more sophisticated as the program went on. The previous transcript clearly shows the rich interplay of language and shared understandings that can develop in the tutoring environment.

The rehearsal stage of the M.R.A.R. model provided problems for the tutors. After the modelling stage the rehearsal stage was skipped as the students attempted to apply what the tutors had demonstrated. Clearly neither the tutor nor the student could see the value in talking through the steps again. Impulsively each child wanted to get on with the sum that was before him/her. There is however some evidence in the reminding scaffold (provided *as* the task was being completed) that the mental rehearsal of the task is important. Tutors provided reminding scaffolds on many different occasions during the experiment. They talked the student through the task as they worked.

The apply stage allowed the tutors to assess the independent abilities of the tutee, which in turn provided a direction for their future instruction. Tutors used the apply part of the model many times each session. Students applied the new strategies through drill, filling in sheets from the Tutor Book and by completing sums that the tutors prepared themselves. Tutors did not use the reflect part of the M.R.A.R. model as often as was suggested during the Tutor Training. After the apply stage tutors encouraged their students to think about why and what they did through the use of metacognitive thought. The emphasis on these metacognitive elements was in part due to the researcher reminding the tutors about their importance before and after tutoring sessions. It is interesting to speculate what would have occurred without the researcher's intervention. The tutoring instruction most probably would have moved backwards and forwards from modelling by the tutor to application by the student.

5.8 Discussion of Tutor Scaffolds Protocol and Tutors' Repair Scaffolds

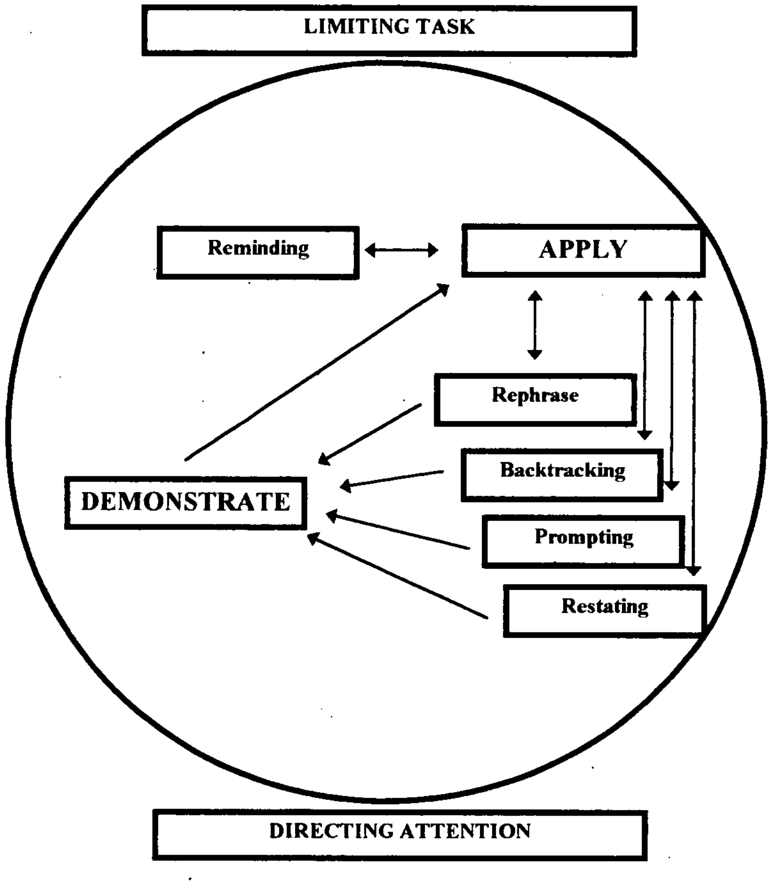
The Tutor Scaffolds Protocol revealed the individuality of the instruction provided by the tutors. Subjects who were capable (Mark, Sarah, Tony) and were using the strategies appropriately did not need extra help. Therefore the tutors did not provide the more basic scaffolds (Appendix 11). These scaffolds included providing, operating and returning to concrete materials and providing visual representations. Conversely tutors with students who were experiencing some difficulty relied on these more basic scaffolds.

The most pertinent finding to come from the study concerns the repair scaffolds that tutors used if the student experienced difficulty, or the tutor perceived some lack of understanding. Tutors consistently checked their students' understanding by drill, questioning points that were unclear and using activities from the Tutor Record Book (Appendix 6).

Five main scaffolds were offered to assist repair of students' understandings. They were *Reminding, Restating, Prompting, Rephrasing and Backtracking*. *Reminding* occurred during the task as the tutor realised the student was having problems. *Restating* occurred after the student had unsuccessfully completed the task. It involved an exact repetition of the stimulus that had occurred before. *Prompting* was a much more substantial scaffold which involved working through the whole problem and allowing the student to contribute a one word answer or phrase that completed the task. *Rephrasing* involved explaining the task in another way. This involved a considerable amount of skill in understanding the task being taught and in coherently explaining it in another context. *Backtracking* was a minor repair strategy. Backtracking was a sophisticated strategy that required the tutor to identify the place where the student had made an error and return to that part of the problem by working backwards from the answer.

In Figure 2 the tutoring process and these repair strategies are explained in a visual representation. Providing the framework for the tutoring environment are the *directing attention* and the *limiting the task* scaffolds: without these the tutoring environment would cease to function. The tutor-student interest is in the task, or step in which the tutors are engaging their students. The tutor's initial role is demonstration; this is followed by opportunities for students to apply the skill. The level of tutor support is dependent on the tutor's perception of the student's independent understanding of the skill. When tutors detected a deficit in students' responses repair scaffolds were provided to assist. After the tutors had elicited the correct response from using repair scaffolds they either returned to demonstration or asked the students to apply the skill independently again.

FIGURE 2. Tutor Repair Scaffolds Model



The selection of the repair scaffolds provided appears to be in part predicated on tutors' perceptions of their students' competencies in the task. Therefore tutors' judgements of the most appropriate repair scaffolds appear to account for the variance in approaches. *Reminding* was used throughout the tutoring environment to remind at key stages of a process. The reminding repair scaffold is different to the others in that it occurs <u>during</u> the task. Reminding therefore was tutor-specific. Out of all of the repair scaffolds offered, tutors used the reminding scaffold the most (Appendix 11). Each tutor had an understanding of the student's prowess in each of the three strategies. For example Daniel knew that his partner was experiencing difficulty with the Near Doubles strategy, in particular the adding of the difference after the smallest number had been chosen to double. Daniel used reminding repair scaffolds at the crucial stage in this process. The reminders of all tutors were mostly in the plural form i.e. 'we' do this next and what are 'we' going to do. This appeared to support the student by indicating that the tutor and the tutee would work together to solve the problem. Reasons for common usage of reminding scaffolds remain unclear. Reminding was perhaps the easiest scaffold to use, in that tutors could intervene throughout the process and guarantee the student was correct.

Prompting appeared to be used when tutors believed that the students' understandings were satisfactory but students had not remembered all the steps logically in the process. The *Prompting* repair scaffold allowed students to get the answer correct and to hear the whole strategy again from start to finish.

Restating on the other hand simply involved repeating a particular stimulus. It was not a particularly successful repair scaffold. Students in some cases simply repeated the error necessitating a return to another more appropriate repair scaffold or demonstration.

Rephrasing involves representing the step or problem in another way. A teacher or experienced child might well provide a rephrasing scaffold in instructional work. Teachers seek to rephrase questions when children are having difficulty by providing examples or by changing contexts. Therefore the *Rephrasing* and *Backtracking* scaffolds can be seen as the most sophisticated of the repair scaffolds. Some tutors did have the expertise or the experience to rephrase or in simple terms, 'put it another way'. The tutors who used rephrasing regularly were Betty, 10 times, (Appendix 11: Betty), Petula, 12 times, (Appendix 11: Petula), Daniel, 20 times, (Appendix 11: Daniel). The remaining three tutors did not use rephrasing as a major part of their repair scaffolds. Matthew did not use rephrasing at all relying instead on reminding and prompting.

Backtracking was identified as a minor repair scaffold. Some tutors worked back to the place where the student had made the error and explained the mistake. Only Matthew (1), Daniel (4) and Petula (5) used backtracking. This scaffold was not used widely for two reasons. Firstly, the tutors did not have the expertise and the experience to take the student back. Secondly, the reminding scaffold provided the instant reinforcement that the tutoring pairs needed to maintain interest in the task.

Tutors developed repair scaffolds that were specific to their students' understanding of the relevant concepts. Repair scaffolds provided were different for the more proficient students: Mark, Sandra and Tony. These students in the Oral Posttest demonstrated their understanding of the three strategies taught. Understandably *Restating* was not used as much with these students. Daniel, (49), Petula, (62), and Rhys (26) used restating much more with their students who were experiencing some difficulty. If students understood the demonstration of the tutor and were succeeding they were unlikely to require restatement of the problem again. Betty's (Appendix 11: Betty) use of *Prompting* declined over a four week period. Her most common repair scaffold was *reminding* and this diminished noticeably in Week Two and Three. In Week Four she used fourteen *reminding* scaffolds. This was probably as a result of revising the three strategies that occurred in this week. Betty used *Restating* six times.

Tutoring Pair 2 (Appendix 11: Lara) provided supporting data about the *reminding* and *restating* scaffolds. *Reminding* was used a total of thirty-two times over the experimental period. In comparison with the other repair scaffolds Betty only *restated* six times and Lara three times. In Tutoring Pair 3 (Appendix 11:

Matthew) data followed a familiar pattern for the more proficient students: *Reminding* of steps totalled forty-two, *Restating* eight. *Prompting* totalled eighteen.

5.9 Differences in Tutoring Styles

Although all tutors took part in a very similar training program and had the same teaching aids tutoring methods varied in the program. The approach of Matthew, in particular, highlights the differences in the individual approaches of tutors. Matthew's tutoring style involved a minimum of discussion and support. Initially he would demonstrate the strategy or sub-skill, then he would allow the student to apply the new skill. His use of repair strategies was minimal. Matthew used reminding regularly, he did not rephrase at all. He restated only eight times during the whole experimental period, and prompted a total of eighteen times.

Matthew's tutoring method seemed to be based on letting the student 'sink or swim' on his own rather than providing the high level of assistance which was provided by other tutors. This was evident in the audio-recordings of this pair. There are many extended periods of silence in which Tony is working independently to apply a strategy. Matthew preferred to tell Tony what to do *as* he was completing the task rather than when he had completed the task and made an error. Matthew's reminding was different to other tutors. His instructions were shorter and appeared to be easily understood and used by Tony. Matthew would first name the strategy Tony was working on and then state the necessary calculation. This is highlighted in the transcript below.

Matthew 2a (203) Reminding of Near Doubles

Student: Six and eight er...

Tutor: Near Doubles! (Long pause).. eight and eight, and take two!

Student: Sixteen! FIFTEEN! FOURTEEN!

Matthew's use of repair strategies seemed to suit Tony. Tony demonstrated his use of the three strategies in the Oral Posttest. The Oral Posttest revealed two interesting features of Tony's use of strategies. When faced with a sum Tony would vocalise the appropriate strategy name first. He would call it out , "Build to Ten!", or "Near Doubles!" This was a new development in Tony's method of doing addition. Tony obviously picked up this way of working from Matthew during the tutoring sessions.

In all Matthew provided the names of the strategies (Uses terminology as a prompt in general dialogue) forty-one times. Rhys also used this method in general discussion on thirty-five separate occasions. Other tutors used cuing of the strategies minimally to assist the tutees. Beyer (1988) found that verbal cues enabled students to apply previously learnt strategies to new situations. Although tutors had not been instructed on cuing and its importance to strategy use they used cues to assist the students to remember the appropriate uses of a strategy. The tutors needed a name to label a way of doing a sum so that they could come back to a teaching point at a later stage in the program.

Another interesting feature of Tony's Oral Posttest was that he verbalised out loud the various steps of the strategy. This appeared to assist him in maintaining his train of thought. The fading of the tutors' role in the tutoring environment is a crucial watershed in handing over control of the newly acquired skill or procedure. The increased responsibility that Matthew placed on Tony appeared to focus and motivate the student to 'own' the new strategy. Conversely Jenny exhibited considerable dependence on her tutor, Petula. Cassandra needed the constant reassurance of her tutor, Rhys, to complete most activities. It appears that the selection and matching of tutors is of vital importance in any tutoring program that involves the ceding of control to the learner of complex cognitive constructions.

The scaffolding functions of the tutor changed during the program. Lundgren (1981, p. 136) first identified the gradual handing over of control by the tutor. Lundgren calls the first stage 'piloting'. The tutor controls the environment rigidly only allowing the student to complete small segments of the task. Control is gradually released to the learner. After piloting the tutor undertakes a 'shadowing' role by providing explanations at critical junctures in the process being taught. As the student's expertise develops the tutor's scaffolding function becomes concentrated more on letting them 'fly on their own.' In Matthew's case the amount of support provided matched the needs of his tutor whereas such an approach would not have been successful with a student of lower ability. This demonstrates that scaffolded instruction provides individualised assistance which is not available in other forms of instruction.

One scaffold that was not provided readily was the completion of the whole task. This relates to the way that tutors perceived their role as teachers. Tutors completed the whole task in total only ten times in the whole program. It appears they saw their roles as getting the students to work rather than doing the work for them.

Theoretical understandings of scaffolded instruction suggests that activities provided by the tutors were within the students' zone of proximal development. Tutors provided learning experiences just beyond the independent abilities of the students. Tutors quickly developed methods of making the material in the Tutor Book more difficult for their students. One of the most popular methods was speed testing. Students were set an amount of time to complete a set of problems for example. Another method was insisting that all answers had to be correct before any stickers would be allocated.

The use of reward stickers proved to be an interesting side issue in the study. Tutors decided that they would use stickers as a reward for good work. The allocation of stickers motivated the students. No stickers were taken back by the tutors and students always received something after each session. Considerable debate has taken place in educational circles over the use of extrinsic versus intrinsic reward systems. In the tutors' case the ends appeared to justify the means; they were quite prepared to use the stickers when they could. The influence that extrinsic rewards had on the efforts of the students is open to interpretation. It did not appear to have any detrimental effects.

5.10 Conclusions

Pressley (1990), who argues strongly for the teaching of thinking skills in schools, discusses the qualities of the "Good Strategy User" model. He presents a description of a child who could be called an expert in strategy use. According to Pressley a good strategy user has at his/her fingertips a variety of strategies that enable him/her to meet new challenges. Good strategy users look for similarities in tasks in the hope that previously learnt thinking skills may be of use. Strategies are coordinated with other useful approaches. Effective strategy users also have the ability to monitor their own thinking and the effectiveness of strategies that have been used. Pressley states that proficient strategy users cognitively evaluate their own performance during and after the task. The self image of poor strategic thinkers and good strategy users appears to be different. Good strategy users see themselves in control of the task, are appropriately reflective and control their anxiety in the learning environment. The knowledge of the good strategy user is broad and versatile: this allows certain tasks or operations to be automated. Although these features have been recounted in isolation, Pressley (1990) maintains that the interaction of these aspects is fundamentally important. Conversely poor strategy users lack a methodical approach and tend not to associate previously learned operations with the task at hand.

Christensen (1991) in her original study questioned the value of the teaching of thinking strategies. She says:

> These data give reason to approach with caution calls to engage in extensive instruction of thinking strategies. It appears that the processes in children's construction of knowledge are quite complex and are influenced by classroom practices quite unintended by the teacher. (p. 67)

There is certainly a need to exercise caution in the teaching of thinking skills that do not have a strong research base to support their use. Some thinking skills programs appear to have been used in classrooms with little research evidence to support their effectiveness. Clearly educational research and practice needs to be closely linked to the search for appropriate strategies that can be effectively taught. Contemporary thought on strategy teaching emphasises choosing a few thoroughly researched strategies and teaching them well rather than attempting to teach many strategies at one time.

Present models for the direct teaching of thinking skills are well researched and documented. Such programs emphasise the modelling of thinking skills and in some cases the direct teaching of strategies involving difficult processes. Opportunities for guided individualised practice are also provided in these programs. Therefore problems of more tightly controlled instructional formats that constrain the development of individualised conceptions of strategy use (Cobb's separation of contexts) are avoided. This overcomes the need for thinking programs that are based purely on providing time for students to discover a strategy. Clearly calls for teachers to spend large amounts of instructional time hoping that children will discover a new strategy are untenable in classrooms already operating in crowded curricula.

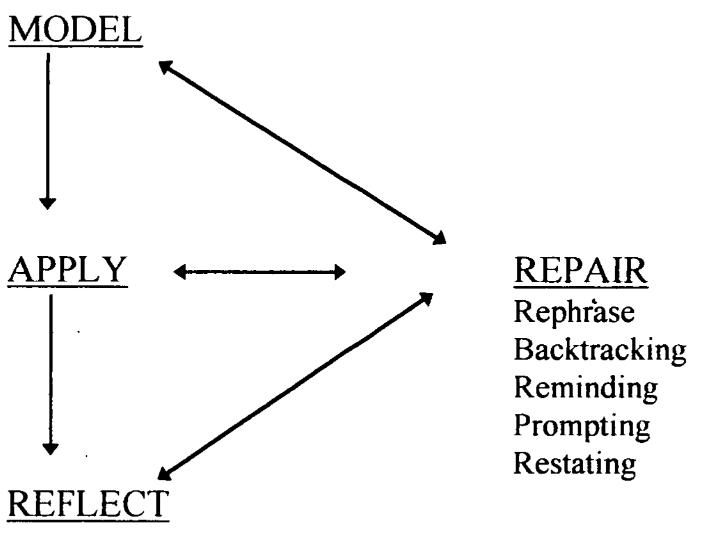
One word of caution should be placed on all discussions about changing the way that children think and operate. To change the way that children complete tasks and consider their world takes time. One shot programs that aim to teach children an approach is at worst going to be ignored by children. At best children will develop a rigid set of rules akin to a recipe when completing the task in the future. This has been observed in the present study. Children's conceptions of addition were based on how they were told to add up rather than any understandings that had been developed. Some children insisted in using blocks even when they could perform addition at an abstract level. Others counted all when they could efficiently use the 'min' model.

5.11 Changes to the M.R.A.R. Model

The M.R.A.R. (Model, Rehearse, Apply, Reflect) Model that was developed to teach three thinking strategies in addition provided the framework for the tutoring environment. The methods that tutors use to correct the misconceptions of tutees are of vital importance. These interventions can play a key role in the acceptance of new strategies into students' existing cognitive routines. Teachers' responses to correct students' thinking in the classroom are dependent on many variables. Educators have long held the belief that explanations of mistakes are more beneficial than showing the child a method that will 'work'. In tutor training for programs that will concern themselves with strategy development it appears that a major emphasis should be placed on the correction processes used by tutors.

Tutoring programs that concentrate on the development of thinking skills need to train tutors in ways of allowing students to "discover" an error thereby developing the students' inner understandings of the process. With these considerations in mind the M.R.A.R. model that was used in this study has been modified. The rehearsal stage has been eliminated. More concentration could be placed on the repair scaffolds by including a repair cycle that could be used by tutors to correct errors. Tutor training would take into account this change of emphasis by explicitly training tutors in appropriate repair strategies. The model has a new step that caters for the correction of tutee errors. Figure 3 shows this new model. It now becomes the **M**odel-**A**pply-**R**eflect-**R**epair (M.A.R.R) model.

FIGURE 3. The M.A.R.R. Model including repair scaffolds.



Correction of errors needs to be made more explicit for the tutors. Development of more mature correction procedures needs to be fostered. Such constrictions on the ways that tutors operate with their partners need to take into consideration the willingness to participate, could be destroyed by overzealous implementation of adult constructed models of tutoring.

The use of scaffolded instruction as *part* of an instructional program in strategy training appears to have considerable merit. Guided discovery is too haphazard if it is based on a hope that children will develop strategies themselves, and too limiting if the guiding involves teaching that is didactic and closed. Tutoring provides a medium in which students involved can be guided towards the appropriate use of strategies. It allows teachers to be in control of the sessions through tutor training and tutor meetings. Tutor training therefore becomes a key aspect. Another important aspect that was highlighted in this study was the importance of tutor-student pairings in the success of tutoring programs. The quality of interpersonal relationships that develop cannot really be foreseen before programs begin and consequently cannot really be assessed. However extensive tutor training and positive tutor attitudes can go a long way to solving problems of unhappy tutor-student relationships.

This study found a similarity in the approaches that tutors used to repair incorrect responses of their students. Some repair scaffolds appear to be more sophisticated than others, requiring the tutor to call on background knowledge and highly developed oral language skills. Two scaffolds in particular are of interest. It appears that Rephrasing and Backtracking were in part modelled from the approaches that tutors had seen teachers using. They were also used because tutors could see that the scaffolds they had first tried were not succeeding. Tutors also learnt to use these scaffolds by listening to the efforts of tutors near them.

In conclusion tutoring and scaffolded instruction must not been seen as a panacea for the problems encountered in the teaching of thinking skills. Scaffolded instruction has several shortcomings that need to be considered. Tutor training needs to be clear and relevant: a clear sense of purpose should be developed. Tutor accountability can be a problem: teachers cannot supervise participants all the time. It is important to stress that scaffolded instruction can be seen as one part of a framework of instructional, organisational and institutional practices that can develop children's thinking strategies.

A great many research studies, and teachers in classrooms around the world have found that peer and cross-age tutoring does "work" in many instructional settings. This study has revealed that tutors' interventions, more particularly the repair strategies, are central to the understanding of tutoring as an instructional mode and more broadly to the understandings of the effect instruction has on children's cognitive frameworks. Christensen (1991) in her work that has been the foundation of this study found that instruction can effect children's organisation of their understanding of the world in ways that are quite unforeseen by teachers.

It is the hypothesis of this paper that these understandings are strongly influenced in tutoring by the timing, appropriateness and sophistication of the repair scaffolds provided by tutors. Matching of tutors and students has long been regarded as a crucial variable in the success of tutoring programs. This study develops added dimensions to this understanding. The matching of the repair scaffolds to the ability and affective state of students is the central core of an effective tutoring relationship. Students who are struggling require careful attention to their problems and repair scaffolds that enable them to develop an ownership of the understandings developed. Therefore the intervention of the tutor is a crucial aspect in changing children's thinking. Tutor training should be refocussed onto *how* the student's conceptions are to be changed rather than concentrating on content material that is to be presented.

It is the development of metacognitive skills through the tutor's scaffolds and more general interactions that is the aim of tutoring programs that have been established to develop thinking skills. Metacognitive thinking enables true understanding and unification of learning tasks rather than students regarding learning activities as a series of isolated events. Through tutoring students and tutors can develop meaningful and lasting impressions of learning.

5.12 Implications for Future Research

Future research on the use of scaffolded instruction in the teaching of thinking skills needs to be focussed on examinations of the role of verbal interaction in the development of children's thinking skills. More work needs to be done on the effect of the different repair scaffolds on children's understandings of new strategies and whether taught tutor interventions are more successful than the natural interventions described in this study.

The understandings about the repair offered by tutors arose during the research project. This highlights the importance of an "action research" approach to studies of tutoring, and to teaching and learning generally. Action research attempts to "learn" as the research unfolds. It is this flexibility that enabled such individualised understandings of tutoring to be developed.

REFERENCES

Allen, V. L. (1976). Children as Teachers-Theory and Research on Tutoring. London: Academic Press.

Ashcraft, M. H. (1982). The development of mental arithmetic: A chronometric approach. Developmental Review, **2**, 213-236.

Ashcraft, M. H. (1987). Children's knowledge of simple arithmetic: A developmental model and simulation. In C.J. Brainerd, R. Kail & J. Bisanz (Eds.), Formal methods in developmental psychology (pp. 302-338). New York: Springer Verlag.

Baird, J., Fensman, P., Gunstone, R., & White, R. (1991). The importance of reflection in Science teaching and learning. Journal of Research in Science Teaching, **28**, 2, 94-95.

Bandura, A. (1986). Social foundations of thought and action: A social cognitive theory. Englewood Cliffs, New Jersey: Prentice Hall.

Baroody, J. A. (1984). The case of Felicia: A young child's strategies for reducing memory demands during mental addition. Cognition and Instruction, **1**, 109-116.

Bausell, R. B. Moody, W. B. & Walzl, F. N. (1972). A factorial study of tutoring versus classroom instruction. American Educational Research Journal, **9**, 592-597.

Beaumont, T. (1994). Cross age tutoring and the development of early readers' word attack strategies. Unpublished Ed. Project. University of Tasmania, Hobart.

Begg, C. B. & Berlin, J. A. (1988). Publication bias: a problem of interpreting medical data. Journal of the Royal Statistical Society, **51**, 3, 1-27.

Beirne-Smith M. (1991). Peer Tutoring in Arithmetic for Children with Learning Disabilities.Exceptional Children, **57**, 4, 330-337.

Bell, E. S. (1981) Training the Tutor: A Comparison of Attitudes toward Writing. Paper presented at the South Carolina Council of Teachers of English Spring Conference.

Belmont, J .M. , Butterfield, E. C. & Ferretti, R. P. (1982). To secure transfer of training to instruct self management skills. In D. K. Detterman & R. J. Sternberg (Eds.), How and how much intelligence can be increased. Norwood, N. J.: Ablex.

Beyer, B. (1988). Developing a thinking skills programme. Boston, Mass.: Allyn & Bacon.

Bloom, S. (1976). Peer and Cross-Age Tutoring in the Schools. Chicago: Chicago Board of Education.

Boehm, G. A. W. (1970). How to teach the esoteric mathematical principle of infinite convergence-and make 6th graders eat it up. Think, Sept.-Oct., 10-14.

Borkowski, J. G., Carr, M. & Pressley, M. (1987). "Spontaneous" strategy use: Perspectives from metacognitive theory. Intelligence, **11**, 61-75.

Briggs, D. (1974, November 1st). Juniors in Charge. Times Educational Supplement. p. 24.

Brownell, W. A., & Chazel, C. B. (1935). The effects of premature drill on third grade arithmetic. Journal of Educational Research, **29**, 17-28.

Brown, A. L. (1987). Metacognition, executive control, self regulation and other more mysterious mechanisms. In F. E. Weihert and R. H. Kluwe (Eds.), Metacognition, motivation and understanding. Hillsdale, N.J.: Erlbaum.

Brown, A. L., Bransford, J., Ferrara, R. & Campione, J. (1983). Learning, remembering and understanding. In Paul H. Mussen (Ed.), Handbook of Child Psychology, 3. New York: John Wiley & Son.

Brown, A. L. & Deloache, J. S. (1978). Skills, plans and self regulation. In R. S. Siegler (Ed.), Children's thinking: What develops?, Hillsdale, New Jersey: Lawrence Erlbaum and Associates.

Brown, A. L. & Ferrara, R. A. (1985). Diagnosing zones of proximal development. In Culture, Communication and Cognition: Vygotskian Perspectives. J.V.Wertsch (Ed.), New York: Cambridge University Press.

Brown, A. L. & Smiley, S. S. (1977). Rating the importance of structural units of prose passages: A problem of metacognitive development. Child Development, **48**, 1-8.

Bruner, J. (1985). Vygotsky: A historical and conceptual perspective. In J. V.Wertsch (Ed.), Culture, communication and cognition: Vygotskian perspectives. New York: Cambridge University Press.

Campione, J. C. , Brown, A. L. & Ferrera, R. A. (1982). Mental Retardation and Intelligence. In R. J. Sternberg (Ed.), Handbook of Human Intelligence. Cambridge: Cambridge University Press.

Carpenter, T. P. & Moser, J. M. (1982). The development of addition and subtraction problem solving skills. In T. P. Carpenter, J. M. Moser & T. A. Romberg (Eds.), Addition and subtraction: A cognitive perspective (pp. 9-24). Hillsdale New Jersey: Lawrence Erlbaum.

Carsrud, A. L. (1984). Graduate student supervision of undergraduate research : increasing research opportunities. Teaching of Psychology, **11**, 4, 203-204.

Chance, P. (1986). Thinking in the Classroom-A Survey of Programs. Columbia University, New York: Teachers College Press.

Christensen, C. A., (1991). Instruction, practice and children's use of thinking skills to solve basic addition facts. In G. Evans (Ed.), Teaching and Learning Cognitive Skills (pp. 51-69). Melbourne: A.C.E.R..

Cifarelli, V. V. & Wheatley, G. H. (1979). Critique of the Thornton study. Journal of Research in Mathematics Education, **10**, 233-234.

Cobb, P. (1988). The tension between theories of learning and instruction in mathematics education. Educational Psychologist, **23**, 87-103.

Cohen, P. A., Kulik, J. A. and Kulik, C-L. C. (1982). Educational Outcomes of Tutoring. A meta-analysis of findings. American Educational Research Journal, **19**, 2, 237-248.

Collier, K. G. (1980). Peer group learning in higher education: the development of higher order skills. Studies in Higher Education, **5**, 1, 55-61.

Cubberly, P.E. (1920). Readings in the History of Education. Boston: Houghton Miffin & Co.

Cumming, J. J. (1988). Children's cognitive performance on the addition facts and more complex sums: The development and the importance of automaticity. Ph.D. thesis, Queensland: University of Brisbane.

Darton, H. F. J. (1909). Bell and the Dragon. Fortnightly Review.

Day, J. D. (1983). The zone of proximal development. In M. Pressley & J. Levin (Eds.), Cognitive strategy research Vol. 1 Psychological foundations. New York Springer Verlag, 155-175.

Davey, B., & Porter, S. (1982). Comprehension rating: A procedure to assist poor comprehenders. Journal of Reading, **26**, 197-202.

Deschler, D. P., Schumaker, J. B. & Lenz, B. K. (1984). Academic and cognitive interventions for learning disabled adolescents (Part 1). Journal of Learning Disabilities, **17**, 108-117.

Dillner, M. (1971). Tutoring by Students-Who Benefits? Florida State University: Florida Research and Education Council.

Duffy, G. G. & Roehler, L. R. (1986). Improving classroom reading instruction: a decision making approach. New York: Random House.

Durkin, D. (1978). What classroom observations reveal about reading comprehension instruction. (Tech. Rep. No. 106). Centre for the study of Reading Urbana Champaign: University of Illinois.

Evans, G. (1991). Teaching and Learning Cognitive Skills. Melbourne: A.C.E.R.

Fantuzzo, J. W., Riggio, R. E. & Dimeff, L. A. (1989). Effects of reciprocal peer tutoring on academic achievement and psychological adjustment: a component analysis. Journal of Educational Psychology, **81**, 173-177.

Feuerstein, R. (1980). Instrumental enrichment: An intervention programme for cognitive modifiability. Baltimore, M.D: University Park Press.

Flavell, J. H. (1977). Cognitive development. Englewood Cliffs, N.J.: Prentice Hall.

Flavell, J. H. (1987). Speculations about the nature and development of metacognition. In F. E. Weinert and R. H. Kluwe (Eds.), Metacognition, motivation and understanding. Hillsdale, N.J.: Erlbaum.

Feldman, R. S. Devin-Sheehan, L & Allen, V. L. (1976). Children tutoring children-a critical review of the research. In V. L. Allen (Ed), Children as Teachers: Theory and Research on Tutoring. New York: Academic Press.

Fitzgibbon, C. T. & Reay, D. G. (1982). Peer tutoring: Brightening up F.L. teaching in an urban comprehensive school. British Journal of Language Teaching, **20**, 1, 39-44.

Frager, S. & Stern, C. (1970). Learning by teaching. Reading Teacher, **23**, 403-405.

Fuson, K. C. (1982). An analysis of the counting on procedure in addition. In T. P. Carpenter, J. M. Moser & T. A. Romberg (Eds.), Addition and subtraction: A cognitive perspective (pp. 67-81). Hillsdale New Jersey: Lawrence Erlbaum.

Gill, J. (1889). Systems of Education. Boston: D.C. Heath.

Ginsburg, H. (1977). Children's arithmetic: The learning process. New York: D. Van Norstrand.

Glynn, T. (1985). Contexts for independent learning. Educational Psychology, **5** , 1, 5-15.

Goldstein, H. & Wickstrom, S. (1986). Peer Intervention effects on communicative interaction among handicapped and non handicapped preschoolers. Journal of Applied Behaviour Analysis, **19**, 2, 209-214.

Goldman, S. R., Pellegrino J. W. & Mertz, D. L. (1988). Extended practice of basic addition facts: Strategy changes in learning disabled students. Cognition and Instruction, **5**, 223-265.

Goodlad, S. & Hirst, B. (1989). Peer Tutoring: A Guide to Learning by Teaching. New York: Kogan Page.

Groen, G. J. & Parkman, J. M. (1972). A chronometric analysis of simple addition. Psychological Review, **79**, 329-343.

Harris, K. R. (1986). The effects of cognitive behaviour modification on private speech and task performance during problem solving among learning-disabled children and normally achieving school children. Journal of Abnormal Child Psychology, **14**, 63-67.

Harrison, G. von & Reay, D. G. (1983). Tutoring in primary schools in the U.S.A. Research in Education, **30**, 65-69.

Hendelman, W. J. & Boss, M. (1986). Reciprocal peer teaching by medical students in the gross anatomy laboratory. Journal of Medical Education, **61**, 8, 674-680.

Johnson, M. & Bailey, J. S. (1974). Cross age tutoring: Fifth graders as arithmetic tutors for kindergarten children. Journal of Applied Behaviour Analysis, **7**, 223-232.

Johntz, W. (1973). An introduction to the evaluation of Project S.E.E.D., Project S.E.E.D. University of California, Berkeley: Lawrence Hall of Science.

Jones, B. F. (April, 1986). Quality and equality through cognitive instruction. Educational Leadership, 6-11.

Kariegnes, M. L., Pascarella, E. T. & Pflaum, S. W. (1980). The effects of peer editing on the writing proficiency of low achieving 10th Grade students. Journal of Educational Research, **73**, 4, 323-329.

Kaye, D. B., Post, T. A., Hall, V. C. & Dineen, J. T. (1986). The emergence of information retrieval strategies in numerical cognition: A developmental study. Cognition and Instruction, **3**, 137-166.

Kendall, P. C. & Braswell, L. (1982). Cognitive behavioural self control therapy for children: A component analysis. Journal of Consulting and Clinical Psychology, **50**, 672-689.

Klosterman, R. (1970). The effectiveness of a diagnostic structured reading programme. The Reading Teacher, **24**, 159-162.

Knight, F. B. (1930). Some considerations of method. In G. M. Whipple (Ed.), Report of the society's committee on arithmetic: Twenty ninth yearbook of the N.S.S.E. (pp. 145-268). Bloomington, Illinois: Public School Publishing Co.

Lancioni, G. E. (1982). Normal children as tutors to teach social responses to withdrawn mentally retarded school mates: maintenance and generalization. Journal of Applied Behaviour Analysis, **15**, 17-40.

Langer, J. A. & Applebee, A. N. (1986). Reading and Writing instruction: Towards a theory of teaching and learning. In E. Rothkopf (Ed.), Review of research in education (Vol **13**, pp. 171-194). Washington D.C.: AREA.

Lawrence, D. (1972). Counselling of retarded readers by non-professionals. Educational Research, **15**, 48-51.

Lortie, D. (1975). Schoolteacher. Chicago: University of Chicago Press.

Lundgren, U. (1981). Model analysis of pedagogical processes. Stockholm: CWK Greenpress

Manning, B. H. (1991). Cognitive self instruction for classroom processes. New York: State University of New York Press.

Meichenbaum, D. (1977). Cognitive behaviour modification: An integrative approach. New York: Plenum Press.

Melargno, R. J. & Newmark, G. (1971). A Tutorial Community concept. In J. Guthrie and E. Wynne (Eds.), New Models of American Education. New Jersey: Prentice Hall.

Moore, P. (1988). Reciprocal teaching and reading comprehension: A review. Journal of Research in Reading, **11**, 3-14.

Mulcahy, R. (1980). Memory: Some selective aspects. In R. Jarmin (Ed.), Issues in Developmental Disabilities. University Microfilms International.

Murfitt, J & Thomas, J. B. (1983).The effects of peer counselling on the self concept and the reading attainment of secondary age slow learning pupils. Remedial Education, **18**, 2, 73-74.

National Assessment of Educational Progress. (1980). Writing achievement, 1969-1979: Results from the Third National Writing Assessment. Vol. 1: 17 year olds (Report 11-L-01). Education Commission of the States: Denver Colorado.

Neches, R. (1987). Learning through incremental refinement procedures. In D. Klahr, P. Langley, & R. Neches (Eds.), Production system models of learning and development (pp. 163-219). Cambridge, M.A.: MIT Press.

Nickerson, R. S. Perkins, D. N. & Smith, E. E. (1985). The Teaching of Thinking. Hillsdale, New Jersey: Lawrence Erlbaum.

Niedermeyer, F. C. (1970). Effects of training on the instructional behaviors of student tutors, Journal of Educational Research, **64**, (3), 119-123.

Niedermeyer, F. C. & Ellis, P. A. (1971). Remedial reading instruction by trained pupil tutors. Elementary School Journal, **71**, **7**, 400-405.

Palincsar, A. S. & Brown, A. L. (1984). Reciprocal teaching of comprehension fostering and comprehension monitoring activities. Cognition and Instruction, **1**, 117-175.

Palincsar, A. S., Brown, A. S. & Martin, S. M. (1987). Peer interaction in reading comprehension instruction. Educational Psychologist, **22**, 231-253.

Paris, S. G., Cross, D. R. & Lipson, M. Y. (1984). Informed strategies for learning. A program to improve reading awareness and comprehension. Journal of Educational Psychology, **76**, 1239-1252.

Paris, S. G. & Lindauer, B. K. (1982). The development of cognitive skills during childhood, In B. Wolman (Ed.), Handbook of developmental psychology (pp. 333-349). New Jersey: Englewood Cliffs.

Posen, B. (1983). Peer Tutoring among Young Offenders: Two experiments. Unpublished M. Ed. Thesis, University of Newcastle upon Tyne.

Pressley, M. (1979). Increasing children's self control through cognitive interventions. Review of Educational Research, **49**, 321-354.

Pressley, M. (1990). Cognitive Strategy Instruction That Really Improves Performance. Cambridge Mass: Brookline Books.

Pressley, M., Borkowski, J. G. & O'Sullivan, J. T. (1985). Children's metamemory and the teaching of learning strategies . In D. L. Forrest-Pressley, G. MacKennon, & T. G. Waller (Eds.), Metacognition, cognition and human performance (pp. 111-115). San Diego, C.A.: Academic Press.

Pressley, M., Borkowski, J. G. & Schneider, W. (1987). Cognitive strategies: Good strategy users co-ordinate metacognition and knowledge. In R. Vasta & G. Whitehurst (Eds.), Annals of child development, Vol. 4 (pp. 89-129). Greenwich C.T.: JAI Press.

Pressley, M. Levin, J. R. & Ghatala, E. S. (1984). Memory strategy monitoring in adults and children. Journal of Verbal Behaviour and Verbal Learning, **23**, 270-288.

Pumfrey, P. (1986). Paired Reading-promise and pitfalls. Educational Research, **28**, 2, 89-94.

Rathmell, E. C. (1978). Using thinking strategies to learn the basic facts In M. N. Suydam (Ed.), Developing Computational Skills (pp 13-38). V.A. National Council of Teachers of Mathematics: Reston.

Rathmell, E. C. (1979). A reply to "Formal thinking strategies: A prerequisite for learning basic facts?" Journal of Research in Mathematics Education, **10**, 374-377.

Rosenthal, T. L. & Zimmerman, B. J. (1978). Social learning and cognition. New York: Academic Press.

Rohwer, W.D. Jr. & Litronik, J. (1983). Age and individual differences in the learning of a memorization procedure. Journal of Educational Psychology, **75**, 799-810.

Rowe, H. (1991). 'Observing' thinking and learning processes. In G. Evans (Ed.), Learning and Teaching Cognitive Skills. Melbourne Australia: A.C.E.R

Schoenfeld, A. H. (1985). Mathematical Problem Solving. Toronto: Academic Press.

Schunk, D. H. (1987). Peer models and children's behaviour change. Review of Educational Research, **57**, 149-184

Schunk, D. H. & Hanson, A. R. (1985). Peer models: Influence on children's self efficacy and achievement. Journal of Educational Psychology, **77**, 313-322

Scott, M. E. (1988). Learning strategies can help. Teaching Exceptional Children 30-33.

Sharpley, A. M.& Sharpley, C. F. (1981). Peer tutoring: A review of the literature. Collected Original Resources in Education (CORE) **5**, 3, 7-C11. Oxfordshire OX143UE: Carfax Publishing Co.

Siegler, R. S. (1987). Strategy choices in subtraction. In J. Sloboda & D. Rogers (Eds.), Cognitive processes in mathematics (pp. 81-106). Oxford: Oxford University Press.

Siegler, R. S. & Jenkins, E. (1989). How children discover new strategies. Hillsdale New Jersey: Lawrence Erlbaum Associates.

Siegler, R. S. & Schrager, J. (1984). Strategy choices in addition:-How do children know what to do? In C. Sophan (Ed.), Origins of Cognitive Skills (pp. 229-293). Hillsdale, New Jersey: Lawrence Erlbaum.

Sindelar, P. T. (1982). The effects of cross age tutoring on the comprehension skills of remedial reading students. The Journal of Special Education, **16**, 2, 199-206.

Sitronik, K. A. (1983). What you see is what you get-consistency, persistency and mediocrity in classrooms. Harvard Educational Review, **53**, 16-31.

Smith, J. H. (1921). Arithmetical Combinations. Elementary School Journal, **16,** 762-770.

Steinberg, R. M. (1985). Instruction on derived fact strategies in addition and subtraction. Journal of Research in Mathematics Education, **16,** 337-358.

Strain, P. S. (1981). The Utilisation of Classroom Peers as Behaviour Change Agents. Newark: Plenum Press.

Svenson, O. (1975). Analysis of time required by children for simple addition. Acta Psychologica, **39**, 289-382.

Svenson, O., Hedenborg, M. & Lingman, L. (1976). On children's heuristics in solving simple additions. Scandinavian Journal of Educational Research, **20**, 60-73.

Swenson, E. J. (1949). Organisation and generalization as factors in learning transfer and retroactive inhibition. In Learning Theory in school situations (pp. 9-39). Minneapolis: University of Minnesota Press.

Theile, C. L. (1938). The contribution of learning to the generalization of number facts. Columbia University, New York: Teacher's College Press.

Thorndike, E. L. (1922). The Psychology of Arithmetic. New York: Macmillan.

Thornton, C. A. (1978). Emphasising thinking strategies in basic fact instruction. Journal of Research in Mathematics Education, **9**, 214-227.

Topping, K. (1987). Peer Tutoring-outcome data from ten projects. Educational Psychology, **7**, 2, 133-45.

VanLehn, K. (1986). Arithmetic procedures are induced from examples. In J. Hiebert (Ed.), Conceptual and procedural knowledge: The case of Mathematics (pp. 133-179). Hillsdale, New Jersey: Lawrence Erlbaum & Associates.

Vygotsky, L. S. (1934/1962). Thought and Language. Cambridge, M.A.: M.I.T. Press.

Vygotsky, L. S. (1978). Mind in Society: The development of higher psychological processes. M. Cole, V. John Steiner, S. Scribner & E. Souberman (Eds.), Cambridge, M.A.: Harvard University Press.

Warner, R. & Scott, S. (1974). Peer Counselling. Personnel and Guidance Journal, **53**, 228-231.

Weinstein, C. E. & Mayer, R. E. (1986). The teaching of learning strategies. In M. C. Wittrock (Ed.), Handbook of research on teaching (3rd ed., pp. 315-27). New York: Macmillan.

Wells, G. & Chang-Wells, G. L. (1992). Constructing Knowledge Together: Classrooms as Centers of Inquiry and Literacy. Portsmouth, N.H.: Heinemann.

Wertsch, J. V. (1979). From social interaction to higher psychological processes: A clarification of Vygotsky's theory. Human Development, **22**, 1-22.

Wheatley, G. A., (1976). A comparison of two methods of column addition. Journal of Research in Mathematics Education, **7**, 145-154.

Whimbey, A. & Lochhead, J. (1982). Problem solving and comprehension (3rd ed.). Philadelphia: Franklin Press.

Wilson, J., & Wing Jan, L. (1993). Thinking for themselves-developing strategies for reflective learning. Melbourne: Eleanor Curtain.

Winter, S. (1986). Peers as Paired Reading Tutors. British Journal of Special Education, **3**, 3, 103-106.

Wise, J. (1964). The History of Education. New York: Sheed-Ward.

Wood, D., Bruner, J. S. & Ross, G. (1976). The role of tutoring in problem solving. Journal of Child Psychology and Psychology and Psychiatry, **17**, 89-100.

Wood, D., Wood, H. & Middleton, D. (1978). An experimental evaluation of four face-to-face teaching strategies. International Journal of Behavioural Development, **1**, 131-147.

APPENDIX 1
LETTER SENT HOME TO PARENTS

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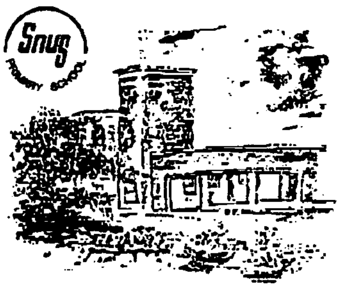
LETTER SENT HOME TO PARENTS



Snug Primary School

PO Box 19
SNUG 7054
Tel: 679 230 Fax 679 650

Dear Parent,

I am inviting you to help me by allowing your child to take part in a number of peer tutoring sessions to help with Maths. I am hoping to find out whether children learn better by this method. Peer tutoring involves older children helping younger children under teacher supervision, and has may benefits including building self confidence.

Under the program proposed at Snug Primary, Grade 6 tutors who have been specifically trained will assist Grade 1 and 2 students in maths number work for four weeks (5 x 25 minute) sessions per week. In order to see what the advantages of this particular method are I have selected students randomly to participate and not because they are experiencing any problems with Maths. Your child is one of those selected. The peer tutoring program is using well established methods and is not in any way "experimental", but because it departs from the usual teacher led methods I am seeking your approval for your child to participate.

The children will be tested before and after the program to find out what changes have occurred and if you wish a summary of the results can be sent to you. Children will be videotaped working with their tutor to record changes in their learning. No individuals will be identified and all data will be treated as confidential. The findings will be used by me as part of a research dissertation for the University of Tasmania.

The project is fully supported by the Principal of our school, Mrs Anne Salewicz and my supervisor Dr J. Watson. We all hope that it will help in the teaching and learning program at the school.

If you have any further queries please do not hesitate to contact me at school on 679230. Please return the consent form (over) and return it to school no later than June 20th.

Thankyou for your cooperation

Yours Sincerely

APPENDIX 2
TEN ITEM ORAL TEST

APPENDIX 2
TEN ITEM ORAL TEST

Oral Pretest Tutoring Experiment 1995

Name..........................

1. 3 + 1= ☐

2. 10 + 5 = ☐

3. 6 + 6 = ☐

4. 2 + 9 = ☐

5. 4 + 6 = ☐

6. 7 + 3 = ☐

7. 8 + 6 = ☐

8. 7 + 10 = ☐

9. 5 + 5 = ☐

10. 8 + 4 = ☐

APPENDIX 3
WRITTEN TEST

APPENDIX 3
WRITTEN TEST
(PAGE 1)

$9 + 2 = \square$

$2 + 10 = \square$

$1 + 7 = \square$

$6 + 7 = \square$

$8 + 9 = \square$

$3 + 2 = \square$

$6 + 5 = \square$

$10 + 2 = \square$

$10 + 8 = \square$

$10 + 1 = \square$

$2 + 3 = \square$

$2 + 7 = \square$

$10 + 3 = \square$

$3 + 10 = \square$

$1 + 1 = \square$

$1 + 10 = \square$

$6 + 2 = \square$

$4 + 10 = \square$

$7 + 7 = \square$

$5 + 1 = \square$

$1 + 4 = \square$

$5 + 3 = \square$

$3 + 9 = \square$

$7 + 4 = \square$

$9 + 8 = \square$

$5 + 8 = \square$

$6 + 4 = \square$

$2 + 1 = \square$

$5 + 6 = \square$

$9 + 5 = \square$

$8 + 10 = \square$

$9 + 3 = \square$

$5 + 2 = \square$

$10 + 9 = \square$

$3 + 1 = \square$

$10 + 6 = \square$

$9 + 4 = \square$

$6 + 1 = \square$

$7 + 9 = \square$

$3 + 7 = \square$

$4 + 1 = \square$

$4 + 5 = \square$

$2 + 6 = \square$

$8 + 8 = \square$

$4 + 2 = \square$

$4 + 4 = \square$

$7 + 6 = \square$

$8 + 5 = \square$

$1 + 2 = \square$

$9 + 6 = \square$

$8 + 4 = \square$

$2 + 2 = \square$

$9 + 10 = \square$

$9 + 7 = \square$

$10 + 7 = \square$

APPENDIX 3
WRITTEN TEST
(PAGE 2)

$8 + 7 = \square$

$5 + 7 = \square$

$5 + 4 = \square$

$10 + 5 = \square$

$8 + 1 = \square$

$6 + 6 = \square$

$5 + 9 = \square$

$2 + 9 = \square$

$7 + 3 = \square$

$8 + 2 = \square$

$8 + 6 = \square$

$2 + 4 = \square$

$2 + 8 = \square$

$4 + 6 = \square$

$5 + 10 = \square$

$8 + 3 = \square$

$7 + 2 = \square$

$2 + 5 = \square$

$3 + 8 = \square$

$9 + 1 = \square$

$1 + 3 = \square$

$1 + 8 = \square$

$6 + 8 = \square$

$7 + 10 = \square$

$4 + 7 = \square$

$7 + 8 = \square$

$7 + 1 = \square$

$4 + 8 = \square$

$7 + 5 = \square$

$6 + 3 = \square$

$1 + 5 = \square$

$4 + 3 = \square$

$6 + 9 = \square$

$3 + 3 = \square$

$1 + 6 = \square$

$9 + 9 = \square$

$6 + 10 = \square$

$1 + 9 = \square$

$10 + 10 = \square$

$3 + 6 = \square$

$3 + 4 = \square$

$10 + 4 = \square$

$3 + 5 = \square$

$5 + 5 = \square$

$4 + 9 = \square$

APPENDIX 4
CONVENTIONS OF TRANSCRIPTION

APPENDIX 4
CONVENTIONS OF TRANSCRIPTION

Conventions of Transcription

Layout	Each new utterance starts on a new line and if more than one line is required to complete the utterance continuation lines are indented Utterances in the oral pretests and oral retests are numbered sequentially from the beginning of the episode for easy reference. In the transcriptions of the tutoring phase of the study utterances are prefaced with a short introduction. Episodes are headed firstly with the tutor's name, the number of the audio tape, the side, and the counter number where the episode began.
-	Incomplete utterances or false starts are shown with a dash, e.g., "Well - er -"
.	Pauses are indicated with a period. In the case of long pauses, the number of periods corresponds to the number of seconds in the pause, e.g., "Yes..I do."
?!	These punctuation marks are used to mark utterances judged to have an interrogative and exclamatory intention.
CAPS	Capitals are used for words spoken with emphasis, e.g., " I really LOVE painting."
< >	Angle brackets are used to enclose words or phrases with which the transcriber felt uncertain.
*	Passages that are impossible to transcribe are shown with asterisks, one for each word judged to have been spoken e.g., "I'll go ***."
	When two speakers speak at once, the overlapping portions of their utterance are underlined.
(Gloss)	Where it is judged necessary, an interpretation of what was said is given in brackets.

(Wells & Chang-Wells, 1992, p. IX)

APPENDIX 5
ORAL PRETEST TRANSCRIPTIONS

SANDRA
TONY
EMMA
JENNY
CASSANDRA
MARK

APPENDIX 5
ORAL PRETEST TRANSCRIPTIONS
SANDRA

1 **S:** 10 + 5 = □ (Sandra set out ten blocks and then 5, then wrote down 15.)

2 **T:** What did you do there? Did you count from one, two, three?

3 **S:** Eleven!

4 **T:** That's interesting! Well done!

5 **T:** (4 + 6 = □) Four and six equals?

6 **S:** TEN! I knew that! It just came into my head!

7 **T:** You're doing well!

8 **T:** (2 + 9 =□) What did you do? Did you put nine in your head?

9 **S:** Yes.

10 **T:** What's two and nine?

11 **S:** Eleven. (6 + 6 =□) (Sandra promptly wrote down the answer.)

12 **T:** How did you do that one?

13 **S:** I just knew that! (7 + 3 =□) Sandra set out seven blocks and three. She counted from seven to ten)

14 **S:** (8 + 6 =□) I'm not sure of this one!

15 **T:** Why not? It looks O.K! (8 + 6 =□ (Sandra took one block from the three in the earlier problem and transferred it to the seven pile. This changed the sum from 3 + 3 =□ to 8 + 2 =□ Then she added four more blocks on.)

16 **T:** Er. You were still using the same blocks and you took counters from one pile to another!..What about the next one? (7 + 10 =□) Can we add on the seven from then?.

17 **T:** What's the answer?

18 **S:** 17!

19 **T:** Well done! (5 + 5 = □) What about this one?

20 **S:** Ten!

21 **T:** I know that you do Maths at home. Do you use blocks at home?

22 **S:** Yes,..sometimes I use dots to count.

23 **T:** I notice you have been doing some dotting with your pen up here too?.What about this one? (8 + 4 =□)

24 **S:** I put them together

APPENDIX 5

ORAL PRETEST TRANSCRIPTIONS

TONY

1 **T:** (3 + 1 =□) How did you do that?

2 **S:** I just knew it! 10 + 5 = 15! I knew that in my head!

3 **T:**(4 + 6 =□, (Tony set out 4 blocks and then 6 blocks and counted all).

4 **S:** (6 + 6 = □) Err ...twelve!

5 **T:** How was that?

6 **S:** I added it.

7 S: (2 + 9 =□) (Tony grabbed for the blocks he built two blocks and built another nine onto it).11 ! .

8 T: That looks very good!... six plus six?

9 **S:** Twelve! (7 + 3 =) (Tony set out seven blocks and three blocks and counted all)

10 **S:** I added it. I put ten there. Then I put on the seven.

11 **T:** But ten isn't first! Can you turn them around in addition?

12 **S:**(Smiling) Yes!

13 O.K.! What did you put first there? (pointing to another example, 8 + 4 =□) The big or the smaller number?

14 **S:** Big! (Tony put out eight blocks and four and counted all.)

APPENDIX 5
ORAL PRETEST TRANSCRIPTIONS
EMMA

Emma worked with blocks with her fingers and despite being questioned on her solution strategies her responses were very quiet. Often she would comment that she had "used her fingers" to work out sums. From the researcher's observations she looked down quite a deal during working out. She could be seen moving her fingers as she glanced down. Reversal of the addends occurred in ($2 + 9 = \square$) and ($7 + 10 = \square$). Emma whispered the number sentences out as she worked. She explained her use of blocks by stating: "The ones that have too much for my fingers, I use the blocks."

APPENDIX 5
ORAL PRETEST TRANSCRIPTIONS
JENNY

1 **T:** We're going to go through these sums .. you can have my magic pen. I'm going to get you to do these and when I ask you I want you to remember how you did them. Think about how you are doing the sums. (3 + 1 =□) What did you do first?

2 **S:** I counted it up like (tapping index finger on desk) one, two, three, then I added the one on.

3 **T:** (10 + 5 = □) You keep going. I'm just taking notes of what's going on. (J setting out sum with blocks: sets out ten blocks and then five separately goes back to count all from one through fifteen). (Working with blocks broke line of ten from previous problem into six and four by eye, counted the six, paused, and then wrote twelve on the answer sheet.) That was interesting! I could see what you did there.

4 **T:** (6 + 6 =□) Did you use the blocks? What happened there?

5 **S:** I got six then I counted up anothersix. <So the overt counting was from 6 to 12 rather than checking that six blocks had been put out.>

6 **S:** (2 + 9 = □) That's hard!

7 **T:** Is it hard? Why?

8 **S:** Because when there's a two and a higher number you can't add it up! .. Because there's a two there you can't add up one, two, three...

9 **T:** So. How are you going to do it?

10 **S:** Use the blocks! (Set out two blocks and nine blocks counted all from the group of two and then onto the nine).

11 **T:** Hmm!.. I see you used your fingers there.. (J. reaches for blocks) Hold on!

12 **S:** (4 + 6 =□)..I said three. one, two,<u>four</u>.

13 **T:** Four-Then you put the six on.. It seems to me you have a bit of trouble when there is a small number at the front of these sums. Let's leave the next one out and look at this one

14 **T:**(7 + 3 =□). Is this easy or hard?

15 **S:** Easy!

16 **T:** What's the answer?

17 **S:** Err...Umm.. I've forgotten it now!..I'll use the blocks? (Counts out seven blocks and three blocks and counts all.) Ten!

18 **T:** Good!

19 **T:** (8 + 6 =□) What about this one? (Puts out blocks, Jenny put three and three together)

20 **T:** Are you sure? We've already have six here! You've got six. You've got to lay out.. How many more? (J. put out eight more and counted all).

21 **S:** Fourteen!

22 **T:**. (7 + 10 =□) (J set out ten blocks and then put up seven fingers. She set out nine fingers by laying them on the table. The she said .ten! and placed a block on the little finger of her left hand. Then Jenny proceeded to count aloud from ten to seventeen.

23 **T:** Oh! I like that!..Tell me what you did!

24 **S:** I got ten and then went eleven, twelve, thirteen, fourteen, fifteen, sixteen, seventeen!

25 **S:** Seventeen!

26 **T:** Very good! You used your fingers and the blocks!. You're doing a great job! Five plus five?

27 **S:** Ten

28 **T:** That was easy! What did you do there? .Did you count all of them?

29 **S:** I had 5 fingers and 5 fingers then I counted them, ten and got ten!

30 **S:**(8 + 4 =□) (J. Set out 8 blocks and held 4 fingers up. She counted eight fingers and 4 blocks).. Twelve!

31 **T:** Lovely work! Well done!

APPENDIX 5

ORAL PRETEST TRANSCRIPTIONS

CASSANDRA

1 **S:** (3 + 1 =□) Three.. four I knew the answer to that one!

2 **T:** (10 + 5 =□) Now how did you do that one?

3 **S:** I said * * then plus five is fifteen. (6 + 6 =□, spent allot of time sitting and moving fingers, then wrote down the correct answer)

4 **T:** Good. What did you SAY?

5 **S:** 6.. 7.. 8.. 9.. 10.. 11.. 12. (2 + 9 =□) Cassandra wrote down the answer straight away without working anything out).

6 **S:** I started with nine and added two more on!

7 **T:** You're doing very well!

8 **T:**(7 + 10 =□) What did you do there?

9 **S:** I started with seven and added ten on.

10 **S:** (5 + 5 =□) I counted them all up!

11 **T:** (8 + 4 =□)That looks very good!.. eight plus four?

12 **S:** (counting all blocks) Err ... twelve

13 **T:** How was that?

14 **S:** I added it

APPENDIX 5
ORAL PRETEST TRANSCRIPTIONS
MARK

1 **T:** (3 + 1 = □) How did you do that one?

2 **S:** . Well,. I just.. put the one onto three

3 **T:** I'm just writing down some notes here to help me remember.. (10 + 5 =□) What did you use there?

4 **S:** I put the five-. er ... onto ten and made it 15.

5 **T:** So you started at ten! Why didn't you return to one.

6 **S:** It's easy to count from ten.

7 **T:** (6 + 6 =□) Err.. What about that one?

8 **S:** I just added six onto it and that makes twelve.

9 **T:** What's seven plus seven then?

10 **S:**...Err (looking down list) Twelve?

11 **T:** Mmm.. O.K! Lets go on.

12 **S:** (2 + 9 = □) Eleven!

13 **T:** How did you do that?

14 **S:** Just added two onto the nine!

15 **T:** You started with nine, but that's at the end of the sentence.

16 **S:** You can do that!

17 **T:** O.K. Very good...I better tick some of these. Great!

18 **S:** I've forgotten how to do a nine!

19 **T:** Put it around the other way.

20 **S:** (8 + 6 = □) Eight add six ... fourteen.

21 **T:**Try the next one!

22 **T:** (7 + 10 = □) What about this one?

23 **S:** Um. I put the seven onto that and made it. Just leave the ten and put the seven on.

24 **T:** You started with the ten and added the seven on. Why didn't you do that here? (points to 2 + 9 = □).

25 **S:** Because ... er. I didn't want to.

26 **T:** five and five?

27 **S:**... ten.

28 **T:** Have you been doing doubles in class?

APPENDIX 6
TUTOR RECORD BOOK ACTIVITY SHEETS

M.R.A.R.

MODEL - Talk your partner slowly through the strategy step by step as you use it. Explain what the **choices** are at each step and **why** you are doing certain things.

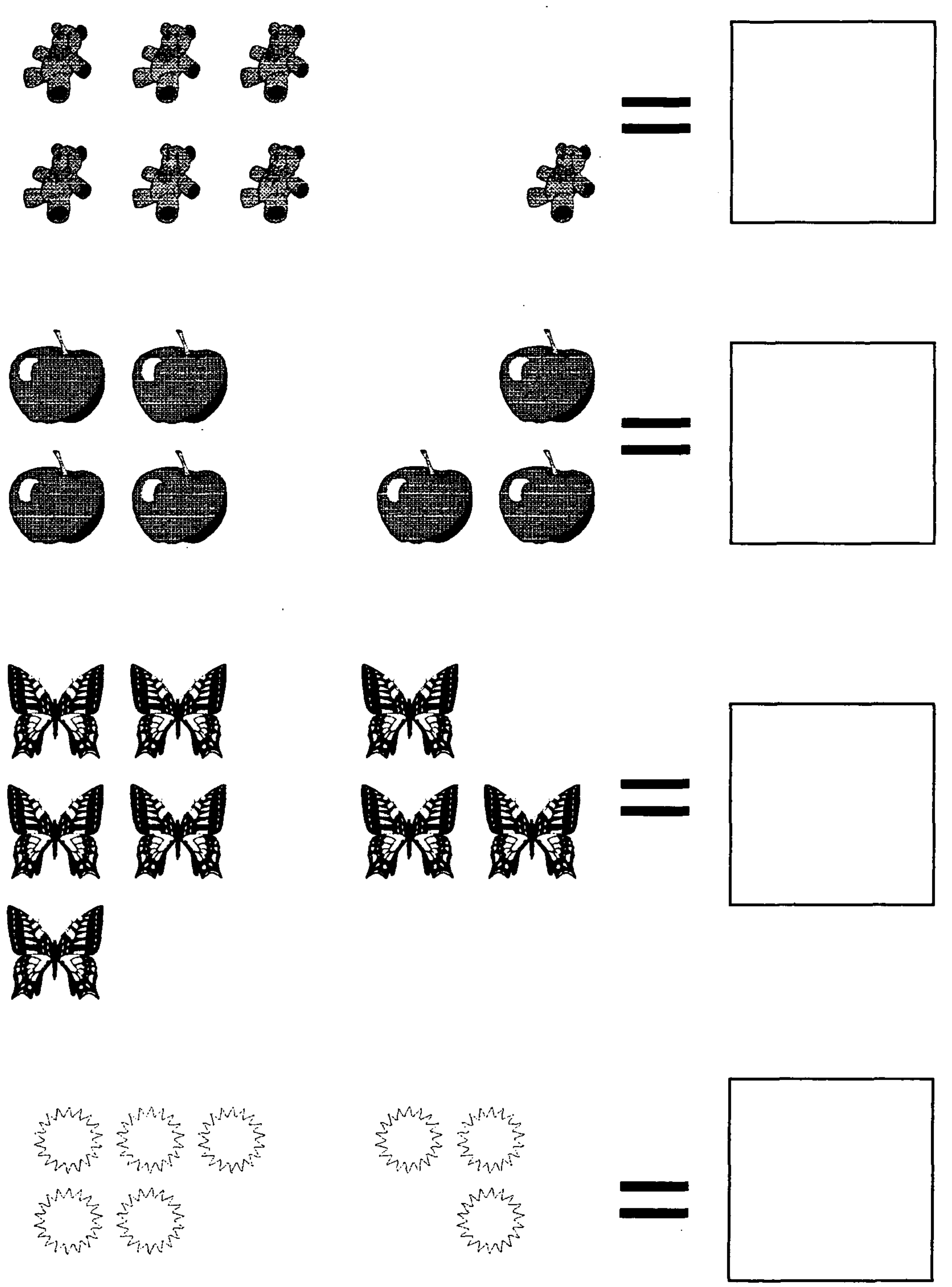
REHEARSE - Let your partner talk you through the strategy. Ask them questions as they do. Try to see where they are going to have problems and help them by asking questions.

APPLY - Let your partner work out the problem. See if you can see what they are doing and where you will need to assist them.

REFLECT - Get your partner to reflect on what they did. Ask them questions like why they did certain things, and what they were thinking of.

APPENDIX 6
TUTOR RECORD BOOK ACTIVITY SHEETS

Min Model Practice Sheet Name.........................



APPENDIX 6
TUTOR RECORD BOOKACTIVITY SHEETS

Min Model Activity Sheet 1 Name......................

APPENDIX 6
TUTOR RECORD BOOK ACTIVITY SHEETS

Min Model Activity Sheet 2 Name......................

APPENDIX 6
TUTOR RECORD BOOK ACTIVITY SHEETS

Min Model Activity Sheet 3 Name......................

2 + 2 =	3 + 4 =
3 + 5 =	7 + 3 =
7 + 2 =	2 + 1 =
8 + 1 =	8 + 2 =
3 + 10 =	4 + 3 =
2 + 4 =	10 + 1 =
6 + 2 =	2 + 8 =
6 + 3 =	9 + 3 =
8 + 3 =	1 + 2 =
9 + 2 =	2 + 7 =
2 + 9 =	1 + 8 =
2 + 5 =	1 + 4 =
3 + 9 =	5 + 3 =
1 + 5 =	2 + 10 =

APPENDIX 6
TUTOR RECORD BOOK ACTIVITY SHEETS

Min Model Test Sheet   Name......................

5 + 3 =	7 + 1 =
3 + 7 =	1 + 6 =
3 + 6 =	10 + 3 =
5 + 1 =	4 + 2 =
1 + 3 =	4 + 1 =
9 + 1 =	1 + 9 =
10 + 2 =	2 + 3 =
3 + 8 =	2 + 10 =
1 + 7 =	3 + 1 =
2 + 6 =	1 + 2 =
1 + 10 =	4 + 3 =
3 + 3 =	5 + 1 =
1 + 1 =	9 + 2 =
5 + 2 =	10 + 2 =

APPENDIX 6
TUTOR RECORD BOOK ACTIVITY SHEETS

DOUBLES Practice Sheet Name..........................

$2 + 2 =$ ☐

$3 + 3 =$ ☐

$4 + 4 =$ ☐

$5 + 5 =$ ☐

$6 + 6 =$ ☐

$7 + 7 =$ ☐

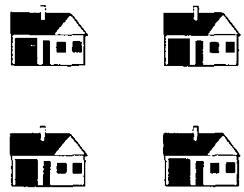
$8 + 8 =$ ☐

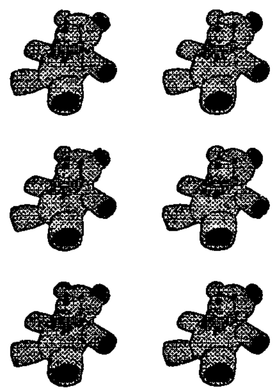
$9 + 9 =$ ☐

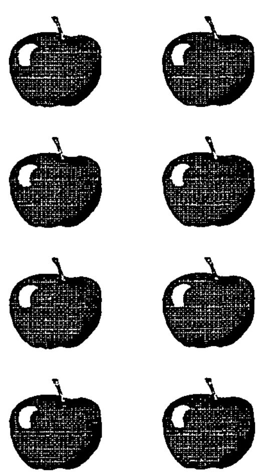
$10 + 10 =$ ☐

Doubles Activity Sheet 1

Name.......................



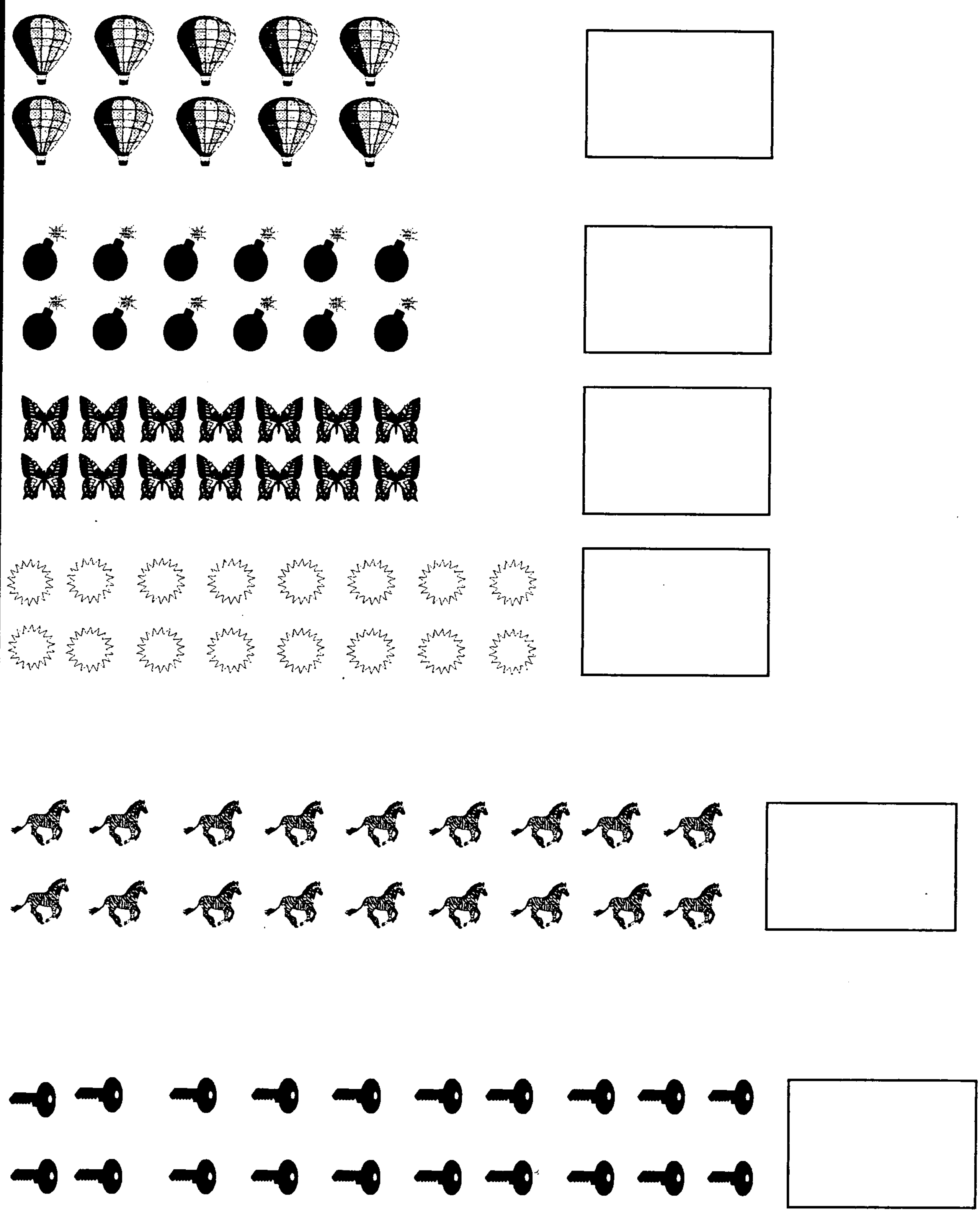




APPENDIX 6
TUTOR RECORD BOOK ACTIVITY SHEETS

Doubles Activity Sheet 2

Name.........................



APPENDIX 6
TUTOR RECORD BOOK ACTIVITY SHEETS

Near Doubles Activity Sheet 1 Name......................

$2 + 3 = \square$	$5 + 6 = \square$
$3 + 2 = \square$	$7 + 6 = \square$
$4 + 2 = \square$	$8 + 6 = \square$
$4 + 3 = \square$	$5 + 7 = \square$
$5 + 3 = \square$	$6 + 7 = \square$
$2 + 4 = \square$	$8 + 7 = \square$
$3 + 4 = \square$	$6 + 8 = \square$
$5 + 4 = \square$	$9 + 7 = \square$
$6 + 4 = \square$	$7 + 8 = \square$
$3 + 5 = \square$	$9 + 8 = \square$
$4 + 5 = \square$	$7 + 9 = \square$
$6 + 5 = \square$	$10 + 8 = \square$
$7 + 5 = \square$	$8 + 9 = \square$
$8 + 10 = \square$	$10 + 9 = \square$
$4 + 6 = \square$	$9 + 10 = \square$

APPENDIX 6
TUTOR RECORD BOOK ACTIVITY SHEETS

Near Doubles Test Sheet

Name......................

2 + 3 =	5 + 6 =
5 + 3 =	8 + 10 =
3 + 2 =	7 + 5 =
4 + 3 =	5 + 7 =
6 + 7 =	8 + 9 =
2 + 4 =	8 + 7 =
6 + 8 =	6 + 5 =
5 + 4 =	8 + 6 =
7 + 6 =	4 + 2 =
6 + 4 =	7 + 8 =
3 + 5 =	9 + 8 =
4 + 5 =	7 + 9 =
10 + 8 =	9 + 7 =
10 + 9 =	3 + 4 =
4 + 6 =	9 + 10 =

APPENDIX 6
TUTOR RECORD BOOK ACTIVITY SHEETS

Build to Ten Activity Sheet 2 Name...................

$8 + 4 = \square$	$9 + 5 = \square$
$9 + 6 = \square$	$4 + 8 = \square$
$5 + 9 = \square$	$5 + 8 = \square$
$10 + 4 = \square$	$9 + 4 = \square$
$8 + 5 = \square$	$10 + 5 = \square$
$4 + 5 = \square$	$4 + 10 = \square$
$8 + 6 = \square$	$10 + 6 = \square$
$9 + 7 = \square$	$5 + 10 = \square$
$8 + 7 = \square$	$10 + 7 = \square$
$9 + 5 = \square$	$6 + 10 = \square$
$9 + 4 = \square$	$7 + 10 = \square$
$4 + 10 = \square$	$10 + 10 = \square$

APPENDIX 6
TUTOR RECORD BOOK ACTIVITY SHEETS

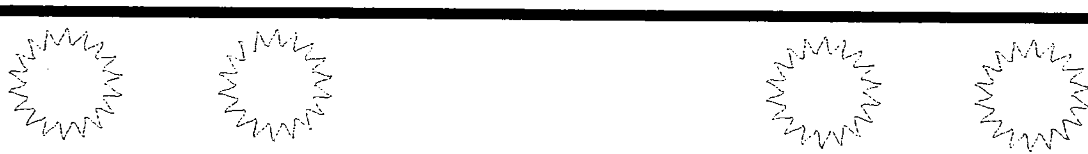
Build to Ten Test Sheet

Name......................

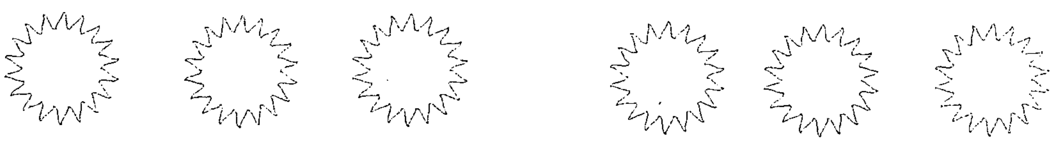
6 + 10 = ☐	8 + 4 = ☐
9 + 6 = ☐	4 + 8 = ☐
5 + 9 = ☐	5 + 8 = ☐
10 + 4 = ☐	9 + 4 = ☐
10 + 10 = ☐	10 + 5 = ☐
4 + 5 = ☐	4 + 10 = ☐
10 + 6 = ☐	8 + 6 = ☐
9 + 7 = ☐	5 + 10 = ☐
8 + 7 = ☐	10 + 7 = ☐
9 + 5 = ☐	9 + 5 = ☐
9 + 4 = ☐	7 + 10 = ☐
4 + 10 = ☐	8 + 5 = ☐

APPENDIX 7
DOUBLES ACTIVITY CARDS

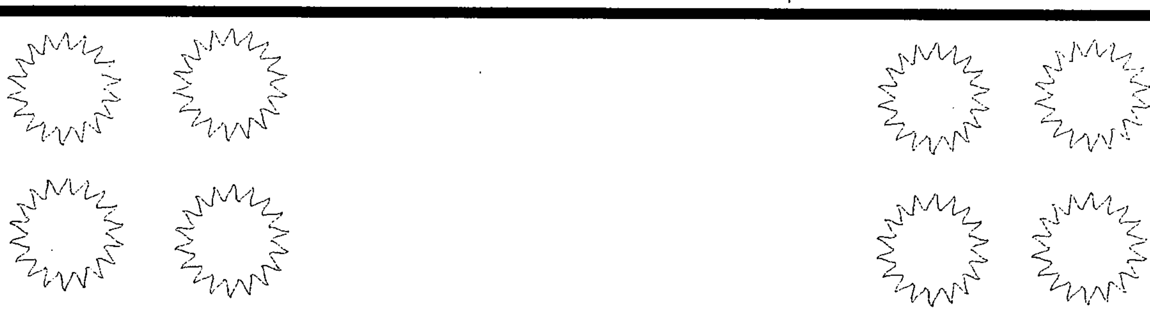
APPENDIX 7
TUTOR ACTIVITY CARDS



$2 + 2 = \square$

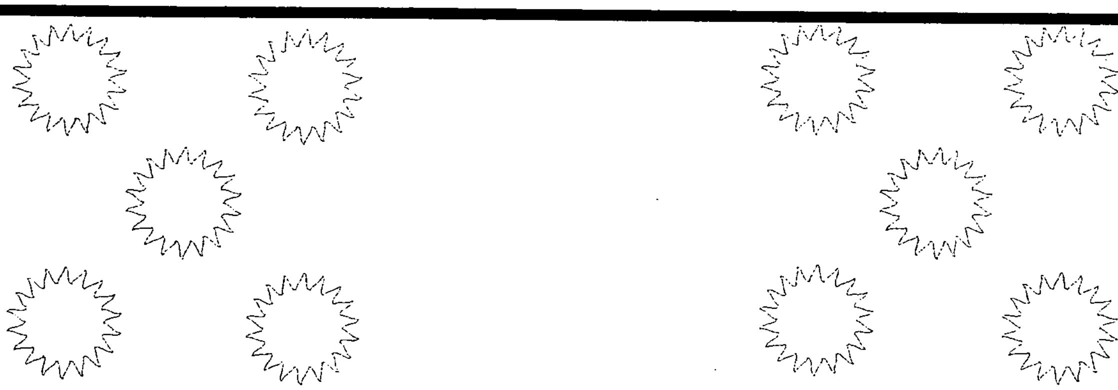


$3 + 3 = \square$



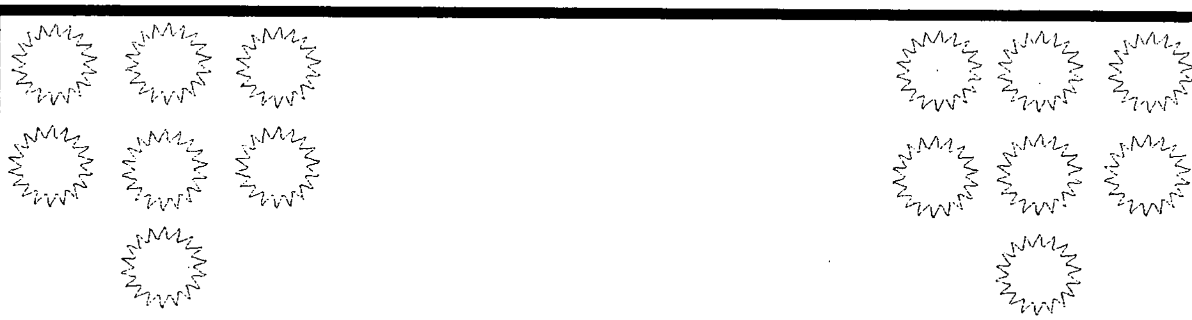
$4 + 4 = \square$

APPENDIX 7
DOUBLES ACTIVITY CARDS



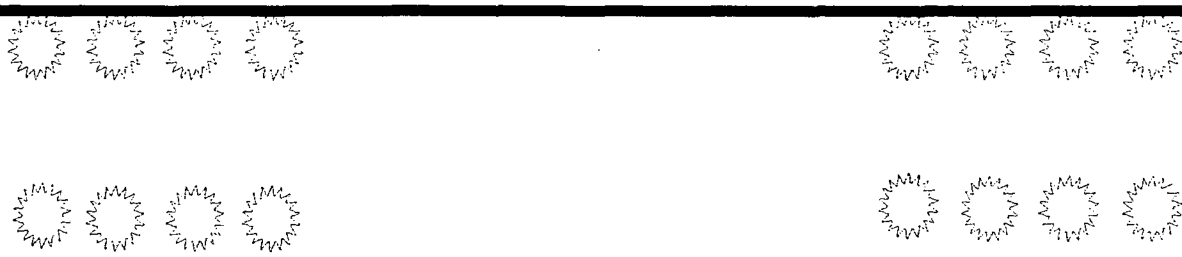
$5 + 5 = \square$

$6 + 6 = \square$

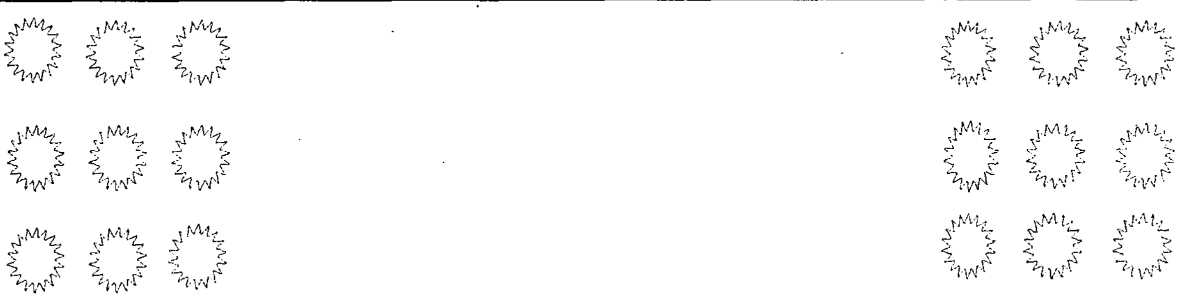


$7 + 7 = \square$

APPENDIX 7
DOUBLES ACTIVITY CARDS



$8 + 8 =$



$9 + 9 =$

APPENDIX 8
TUTOR CUE CARD

APPENDIX 8
TUTOR CUE CARD

CUE CARD : WHEN TO USE THE STRATEGIES

MIN MODEL - Use when one number is 1, 2 or 3.

5 + 2 = 7 + 1 = 2 + 6 = 3 + 7 = 4 + 1 =

NEAR DOUBLES - Use when one of the numbers is one of two away from a doubles fact.

8 + 6 = 7 + 6 = 4 + 5 = 5 + 6 = 5 + 7 =

BUILD TO TEN- Use when one numbers is 8 or 9.

9 + 5 = 8 + 5 = 6 + 9 = 9 + 4 = 6 + 8 =

APPENDIX 9
TUTOR RECORD CARD

APPENDIX 9
TUTOR RECORD CARD

Student Record of Tutoring: Tutoring Experiment 1995

Min Method: Student Record

Min Method Using Blocks.	Min Method: Using Pictures.	Min Method: Thinking

Near Doubles Method

Near Doubles Method Using Blocks.	Near Doubles Method: Using Pictures.	Near Doubles Method: Thinking

Build to Ten Method

Build to Ten Method Using Blocks.	Build to Ten Method: Using Pictures.	Build to Ten Method: Thinking

APPENDIX 10
TUTOR PROTOCOL RECORDING SHEET

APPENDIX 10
TUTOR PROTOCOL RECORDING SHEET

Scaffolded Instruction.	Week 1 (Min)	Week 2 (Near Doubles)	Week 3 (Build to Ten)	Week 4 (Revision - Teaching the appropriate use of the three strategies)	Total
Relating counting materials to children's interest level.					
Operating Concrete materials.					
Providing concrete materials					
Returning to concrete materials.					
Providing visual representations					
Reminding of steps.					
Breaking into simple steps.					
Restating.					
Prompting					
Rephrasing					
Backtracking					
Highlighting similarities.					
Restating the task into a simpler number sentence.					
Decomposition of problem into known fact.					
Using terminology in teaching. Count on!					
Organisational scaffolds					
Revising Get the student to talk through the session before.					
Directing Attention					
Limiting task					
Metacognitive thought					
Completion of the whole task.					

APPENDIX 11
TUTOR SCAFFOLD PROTOCOLS

DANIEL
PETULA
BETTY
LARA
MATTHEW
RHYS

APPENDIX 11
TUTOR SCAFFOLD PROTOCOLS

DANIEL

Scaffolded Instruction.	Week 1 (Min)	Week 2 (Near Doubles)	Week 3 (Build to Ten)	Week 4 (Revision - Teaching the appropriate use of the three strategies)	Total
Relating counting materials to children's interest level.					
Operating Concrete materials.	3		7		11
Providing concrete materials	1		1		2
Returning to concrete materials.			5		5
Providing visual representations	1				1
Reminding of steps.	24	22	13	12	71
Breaking into simple steps.	7		6	5	18
Restating.	20	11	10	8	49
Prompting	7	8	5	5	25
Rephrasing	4	5	7	4	20
Backtracking	1	2		1	4
Highlighting similarities.					
Restating the task into a simpler number sentence.	1				1
Decomposition of problem into known fact.					
Using terminology in teaching. Count on!	2	1		3	5
Organisational scaffolds	1	2	2	1	6
Revising: Get the student to talk through the session before.	7	4	9	5	25
Directing Attention	22	18	12	15	57
Limiting task	22	16	14	8	60
Metacognitive thought	5	6	11	7	29
Completion of the whole task.	1				1

APPENDIX 11
TUTOR SCAFFOLD PROTOCOLS

PETULA

Scaffolded Instruction.	Week 1 (Min)	Week 2 (Near Doubles)	Week 3 (Build to Ten)	Week 4 (Revision - Teaching the appropriate use of the three strategies)	Total
Relating counting materials to children's interest level.	3		1		4
Operating Concrete materials.	8	18	6	3	35
Providing concrete materials	6	2	5	3	16
Returning to concrete materials.	1	1	3		5
Providing visual representations	4				4
Reminding of steps.	11	17	17	18	63
Breaking into simple steps.	11	9	5	9	34
Restating.	12	12	18	20	62
Prompting	12	10	13	20	55
Rephrasing	4	4	3	1	12
Backtracking	2	2		1	5
Highlighting similarities.	3				3
Restating the task into a simpler number sentence.	3	1			4
Decomposition of problem into known fact.	1				3
Organisational scaffolds	9	1			10
Using terminology in teaching. Count on!	5	1		4	10
Revising: Get the student to talk through the session before.	7	4	2	2	15
Directing Attention	5	4	3	2	14
Limiting task	4	7	8	13	32
Metacognitive thought	14	7	6	5	32
Completion of the whole task.	1	1	1	2	5

APPENDIX 11
TUTOR SCAFFOLD PROTOCOLS

BETTY

Scaffolded Instruction.	Week 1 (Min)	Week 2 (Near Doubles)	Week 3 (Build to Ten)	Week 4 (Revision - Teaching the appropriate use of the three strategies)	Total
Relating counting materials to children's interest level.					
Operating Concrete materials.	6		1	1	8
Providing concrete materials	1		8		9
Returning to concrete materials.					
Providing visual representations					
Reminding of steps.	23	5	6	14	48
Breaking into simple steps.	1				1
Restating.	6				6
Prompting	11	8	5	5	29
Rephrasing	4		6		10
Backtracking					
Highlighting similarities.					
Restating the task into a simpler number sentence.					
Decomposition of problem into known fact.	3				3
Using terminology in teaching. Count on!	1		7	10	18
Organisational scaffolds	2	3	2	4	11
Revising: Get the student to talk through the session before.	3	3	1	2	9
Directing Attention	7	3	2	1	13
Limiting task	15	2		4	21
Metacognitive thought	11	5	6	5	27
Completion of the whole task.					

APPENDIX 11
TUTOR SCAFFOLD PROTOCOLS

LARA

Scaffolded Instruction.	**Week 1 (Min)**	**Week 2 (Near Doubles)**	**Week 3 (Build to Ten)**	**Week 4 (Revision - Teaching the appropriate use of the three strategies)**	**Total**
Relating counting materials to children's interest level.					
Operating Concrete materials.			2	1	3
Providing concrete materials	4		5	2	11
Returning to concrete materials.					
Providing visual representation					
Reminding of steps.	10	6	9	7	32
Breaking into simple steps.					
Restating.	1			2	3
Prompting	4	3	7	5	19
Rephrasing	1			1	2
Backtracking					
Highlighting similarities.	2			1	3
Restating the task into a simpler number sentence.					
Decomposition of problem into known fact.			1	1	2
Using terminology in teaching. Count on!		3	6	5	14
Organisational scaffolds					
Revising: Get the student to talk through the session before.					
Directing Attention	5	4	4	5	18
Limiting task	2	2	4	3	11
Metacognitive thought	2	4	6	8	20
Completion of the whole task.				1	1

APPENDIX 11
TUTOR SCAFFOLD PROTOCOLS

MATTHEW

Scaffolded Instruction.	Week 1 (Min)	Week 2 (Near Doubles)	Week 3 (Build to Ten)	Week 4 (Revision - Teaching the appropriate use of the three strategies)	Total
Relating counting materials to children's interest level.					
Operating Concrete materials.	2	2	5	5	14
Providing concrete materials	2	2	4	2	10
Returning to concrete materials.			5		5
Providing visual representations					
Reminding of steps.	11	11	11	9	42
Breaking into simple steps.				3	3
Restating.		2	2	4	8
Prompting	6	3	4	5	18
Rephrasing				1	1
Backtracking	1				1
Highlighting similarities.					
Restating the task into a simpler number sentence.		1			1
Decomposition of problem into known fact.					
Using terminology in teaching. Count on!	16	12	5	8	41
Organisational scaffolds					
Revising: Get the student to talk through the session before.	1		1		2
Directing Attention	13	13	14	6	36
Limiting task	12	11	6	5	33
Metacognitive thought	4	5	4	2	15
Completion of the whole task.					

APPENDIX 11
TUTOR SCAFFOLD PROTOCOLS

RHYS

Scaffolded Instruction.	Week 1 (Min)	Week 2 (Near Doubles)	Week 3 (Build to Ten)	Week 4 (Revision - Teaching the appropriate use of the three strategies)	Total
Relating counting materials to children's interest level.					0
Operating Concrete materials.	1		5	2	8
Providing concrete materials	5		4	4	13
Returning to concrete materials.	6		3	2	11
Providing visual representations					0
Reminding of steps.	4	15	12	12	42
Breaking into simple steps.	1	2	2	3	8
Restating.	1	7	12	6	26
Prompting	2	16	8	4	30
Rephrasing	1				1
Backtracking					
Highlighting similarities.	6	2	2	1	11
Restating the task into a simpler number sentence.	1				1
Decomposition of problem into known fact.	1				1
Using terminology in teaching. Count on!	4	5	15	11	35
Organisational scaffolds	3	4	5	5	17
Revising: Get the student to talk through the session before.	2	4	3	2	11
Directing Attention	3	13	20	7	43
Limiting task	6	12	7	9	34
Metacognitive thought	1	14	12	6	33
Completion of the whole task.		2	1		3

APPENDIX 12
ORAL POSTTEST TRANSCRIPTIONS

SANDRA
TONY
EMMA
JENNY
CASSANDRA
MARK

APPENDIX 12
ORAL POSTTEST TRANSCRIPTIONS
SANDRA

1 **T:** (10 + 5 =□) O.K.! What did you do there?

2 **S:** Counted on!

3 **T:** (6 + 6 =) What about this one?

4 **S:** I knew that!, counted on!

5 **T:**(4 + 6 =□)What did you do there?

6 **S:** I counted on four.

7 **T:** What else could you have done?

8 **S:** Take off two from double six.

9 **T:** (7 + 3 =□) But, you seem to find counting on easier? Mmm. I know what you did there - counted on?

10 **S:** (S.nods)

11 **S:** (8 + 6 =□).. fourteen! (smiles)

12 **T:** (7 + 10 =□) How did you do that one Sandra?

13 **S:** I knew that one!

14 **S:** (5 + 5 =□) Ten! I know that!

15 **T:** (8 + 4 =□) What do you here?

16 **S:** Build to ten! (whispers)

17 **T:** Put two onto the eight?

18 **S:** Yes!

APPENDIX 12
ORAL POSTTEST TRANSCRIPTIONS
TONY

1 **S:** (5 + 5 =□)... Ten. Doubles! (doubles more whispered)

2 **S:** (8 + 4 =□) Err ... um... Count on! (writes down answer)

3 **T:** O.K. Tony, can you start (watching sheet) (10 + 5=□).What did you do there?

4 **S:** I .. just knew it in my head . easy!

5 **T:** Why was it easy?

6 **S:** I just put five on ten!

7 **T:** What about the next one?

8 **S:** (2 + 9 =□) It's even .. twelve!.Count on!

9 **T:** Which one did you start with Tony?

10 **S:** NINE! ten, eleven.

11 **T:** Very good.

12 **S:**(4 + 6 =□) (looks into distance) Double six. Minus two!

13 **T:** What's that then?

14 **S:** Ten!

15 **T:** Excellent! Double six minus two, wow!

16 **S:**(7 + 3 = □) T-Ten .. counting on!

17 **S:** (8 + 6 =□) Double six .. add two

18 **T:** Why?

19 **S:** Double eight is too big!

20 **S:**(7 + 10 =□) Seventeen!. just knew that!

21 **S:**(5 + 5 =□) Double that ... ten!

22 **S:** (8 + 4 =□) Count on!

23 **T:** Is there another way you could do that?..What about build to ten?

24 **S:** Just put eight there, (points at desk top) um ...

25 **T:** Do you need blocks?

26 **S:** Yep... (looks at bracket then pulls bracket towards himself) .Eight and four, build to ten! (Build to ten said as a whisper) one, two, three, four, five, six, seven, eight. four. Put two in... (moves two from group of four to group of eight).Then you count on that! (pointing)

27 **T:** Ten and what?

28 **S:** Twelve!

29 **T:** That's terrific! In fact its amazing how much you've picked up!

APPENDIX 12
ORAL POSTTEST TRANSCRIPTIONS
EMMA

Introduction

Emma was restless, dropped her pencil and was difficult to maintain on task. Of the sums not mentioned in this transcript most were solved using counting on.

1 **T:** (3 + 1 =□) That was easy wasn't it!

2 **S:** Yep!

3 **T:** (10 + 5 =□) What about that one?

4 **S:** Um ... I knew it!

5 **T:** (6 + 6 =□) Six and six. What kinds that?

6 **S:** Double! (Writes down answer)

7 **T:** Good going!

8 **S:** Which one's next?

9 **T:** Four and six!

10 **S:** Ten!

APPENDIX 12
ORAL POSTTEST TRANSCRIPTIONS
JENNY

1 **T:** (3 + 1 = □) You counted on (J. Nodded)

2 **S:** (10 + 5 = □) Fifteen!

3 **T:** Counted on from ten.

4 **S:** Yes!

5 **T:** (6 + 6 =□)Good! .What happened there?

6 **S:** Knew that one!

7 **T:** (2 + 9 =□)*** I put the nine first!

8 **T:** You didn't need the blocks? Why didn't you use them?

9 **S:** Don't need them.

10 **T:** O.K. What about some doubles? Seven and seven?

11 **S:**.. fourteen!

12 **T:** Nine and nine?

13 **S:**(moving fingers staring at paper) .. Eighteen!

14 **T:** (4 + 6 =□) O.K. *** What happened there?

15 **S:** I count on from the big one! (Looking at fingers) .. fourteen <appeared to count on>

16 S: (7 + 10 =□)..Seventeen!

17 **T:** That's good J.

APPENDIX 12
ORAL POSTTEST TRANSCRIPTIONS
CASSANDRA

1 **S:** (10 + 5=□) Is that a five?

2 **T:** Yes!. You can hardly read that photocopy ... Here! (swaps to new sheet)

3 **T:** (10 + 5=□) How did you do that?

4 **S:** Put ten in my head and added on five!

5 **T:** Excellent!

6 **S:** (6 + 6 =□) Six and six...Twelve..Doubles!

7 **T:** Good girl!

8 **T:** (2 + 9 =□) You counted on there to get that!

9 **S:** (4 + 6 =□) Mmm, C. counted on from the larger addend)

10 **S:** (8 + 6 =□ (whispers) eight!... (looks at fingers than writes down answer).

11 **S:** (7 + 10 =□) Is that right?

12 **T:** Sure is! Well done!

13 **S:** (5 + 5 =□) Five plus five is ten.

14 **S:** (8 + 4 =□) I knew that! Er .. (looks at fingers)

15 **T:** What did you do?

16 **S:** Counted on!

APPENDIX 12
ORAL POSTTEST TRANSCRIPTIONS
MARK

1 **T:** (3 + 1 =□) That was nice and easy to start with Mark?

2 **S:** Yes!

3 **T:** (10 + 5 =□) What's the next one? ... How did you do that?

4 **S:**.. Just by taking the zero away and putting the five on.

5 **T:** So you just moved the zero. O.K!

6 **T:** (6 + 6 =□) How did you know that one?

7 **S:** Um ... doubles!

8 **T:** Good boy! Excellent!

9 **T:** (2 + 9 =□) Good! What did you do there?

10 **S:** Well er .. just by taking one away from the two .. that's ten.

11 **T:** Right I see, Mmm.

12 **T:** (4 + 6 =□) What happened there?

13 **S:** Um... Counted from 6

(Some sums were completed with some scanning of the other sums-at one stage Mark said pointing to 10 + 5 =□ and then 7 + 10 =□ they're the same!

14 **T:** (8 + 4 =□) What did you do?

15 **S:** Um,.. just took .. ten . away from . eight.

16 **T:** Ten! you've got TWO left! Then you had what?

17 **S:** Eleven!

18 **T:** Are you sure its eleven?

19 **S:** Twelve!

20 **T:** You went the wrong way? (Mark nods).